United States
Department of
Agriculture

Forest Service

Forest Pest
Management

Davis, CA

FIFTH REPORT

NATIONAL STEERING COMMITTEE FOR MANAGEMENT OF SEED, CONE, AND REGENERATION INSECTS

Healthy Forests
Make A World
Of Difference

FPM 93-13
August 1993

Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.

FPM 93-13
August, 1993

Fifth Report

National Steering Committee for Management of Seed, Cone, and Regeneration Insects

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FIFTH REPORT

National Steering Committee - Management
Of Seed, Cone, and Regeneration Insects

A Report of the Placerville, CA
Meeting - June 28-July 1, 1993

August 17, 1993

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I. INTRODUCTION

A. Place and Purpose of Meeting

The 1993 meeting of the National Steering Committee for management of Seed, Cone, and Regeneration Insects met at Placerville, CA, June 28-July 1, 1993. The meeting was hosted by Nancy Rappaport, PSW, Albany. The committee spent two days in meetings and another visiting the Placerville Nursery and Forest Hill Seed Orchard. The purpose of the meeting was to identify Technology Development needs and to develop the format and goals of a 5-Year Tactical Plan for seed, cone, and regeneration insects.

B. Attendees

Larry Barber	R-8/FPM (Asheville, NC)
Jed Dewey	R-1/FPM (Missoula, MT)
John Dale	R-5/FPM (San Francisco, CA)
Tom Hofacker	WO/FPM (Washington, DC)
Alex Mangini	R-8/FPM (Pineville, LA
Nancy Rappaport	PSW/FIDR (Albany, CA)
Dave Rising	MTDC (Missoula, MT)
Roger Sandquist	R-6/FPM (Portland, OR)
John Taylor	R-8/FPM (Atlanta, GA)
Jack Stein*	PSW/FIDR (Albany, CA)
Jack Barry	WO/FPM (Davis, CA)

* Non-member

C. Evolving Emphasis of Committee

Current and future emphasis will be influenced by the following:

. International forestry is receiving more emphasis.

. Genetic improvement for intensive timber production on smaller acreages of Federal, State, Private lands - those set aside in the future for primary purpose of producing timber.

- Ecosystem management regeneration and ecosystem functions (see Appendix D).

- Tree and other plant seed for ecosystem restoration and management - eg white pine, dogwood, butternut oaks, shrubs, forbes, grasses, and others.

- Regeneration that includes plantations, administrative sites, non-wild sites, special seed collection sites, special high interest tree ecosystem and restoration sites.

- Protection of seedlings in plantations and protection of trees during orchard establishment.

II. COMMITTEE MEMBER REPORTS

Following are comments recorded during the meeting. For detail reports submitted by committee members see the Appendix A.

Tom Hofacker (WO/FPM)

- WO/FPM is emphasizing international forestry.

- New beetles showing up in Lake States - common European pine shoot beetle which effects Scotch pine; also two other possible insect introductions of forestry importance. These are being closely monitored.

John Dale (R-5)

- Not actively involved in cone and seed work at the moment.

- In anticipating future work in the area of cone and seed and regeneration insects in California, we should keep in mind the reduced demand for tree seedlings on Federal lands.

- Variety of species grown in Forest Service nurseries has increased.

Nancy Rappaport (PSW)

- Conducting a study in rust resistant sugar pine to control seed and cone insects with Asana. This study is in cooperation with FPM, MTDC and Sierra National Forest. A spray system designed by MTDC has been installed in three trees, each approximately 120' tall. Preliminary results are encouraging.

- Nancy distributed a draft version of a tactical seed, cone, and regeneration insect plan for the committee to review.

Jed Dewey (R-1)

- Restoration of western white pine sites in R-1 is placing a high demand on white pine seed. There is less emphasis on Douglas-fir and ponderosa pine.

- R-1 has a need for alternatives to chemical insecticides.

- It's important to reduce rates of chemical insecticides now being used.

- A hydraulic sprayer is used to apply permethrin (Pounce), 1-3 times/year, to control seed bugs at the Coeur d' Alene seed orchard.

- A tip moth (Rhyacionia probably zozana) is a concern in a 20 acre ponderosa pine early selection trial plantation. Carbaryl was applied to the 1-2 foot tall trees, initially in early March, and again in early April.

- White bark pine cones and seeds are a critical food for the grizzly bear. Concerns for maintaining this food source are heightened as the tree specie is being seriously impacted by white pine blister rust and the mountain pine beetle.

- There's an excellent 1993 larch seed crop in R-1 that may provide a 10-year seed supply from some areas.

Roger Sandquist (R-6)

- Douglas-fir seed orchards on west side of the Cascades are currently being managed to protect investments as the need for seed is reduced. Certain orchards, ex. Beaver Creek near Corvallis, Oregon are replacing first generation grafted parents with genetically tested selections from 15-year progeny tests.

- There is an increasing need for ponderosa pine seed and seedlings on east side of Cascades.

- Blister rust resistant western white pine continues to be in high demand, especially where it can replace root disease susceptible tree species.

- There is much interest in the establishment of adapted native vegetation (non-forest tree) for a variety of reasons.

- Entomologists and pathologists are being called upon to provide technical assistance on non-pest related issues concerning insects and fungi. This is a result of ecosystem management and a greater emphasis on biodiversity and functioning ecosystems.

- A description: In the context of insects in young forests (young trees in a variety of situations such as plantations, under older forest canopy, or an unevenaged or uneven height management scenario) the terminology <u>ecosystem function</u> includes the following processes as examples:

  pollinators
  wood and litter degraders
  nutrient recyclers
  parasites and predators
  prey
  soil aerators

<u>Larry Barber</u> (R-8)

- Activities include work with light traps, pheromone traps, and ground sprayers. Rates for ground sprayers - hydraulic 500 g/a; other orchard sprayers 100 g/a; and Rotomist 100 g/a.

- Use of Bt in seed orchards became operational for control of cone worms in 1991, thanks to 1987-90 Technology Development funds that supported field evaluation. Bt is applied at 1 gal/A, 17 BIU mixed 1:1 with water. Congratulations to Larry and his colleagues and thanks to the Technology Development Program.

- When Asana is applied by air the SE uses only 1/10 of the ground spray label rate.

- Rates for Guthion have been reduced from 3 lbs/A to 2 lbs/A. (Further reduction is possible and should be investigated.)

- Ground sprayers are adequate for trees only up to 25 feet tall.

- Bt is being applied by aircraft at 1 liter per hectare (1.2 g/a) using 8003 nozzles.

- Guthion should be retained but should use lower rates. Its use is on small acreage so minimal environmental impact. There are no environmental data-gaps for non-food crops.

<u>Alex Mangini</u> (R-8)

- Asana has been demonstrated to be as effective as Cygon.

- R-8, through a Technology Development Project, has developed a ground sprayer that simulates aerial spraying. Scott Cameron and his technician did a great job of developing the system. It is also being used to evaluate FSCBG for expanded use in seed orchards.

- Bt (Foray 48B) provides effective tip moth control - later spray more effective.

- Need for seed in the East as in the West is caught-up in the transition to ecosystem management.

- Committee has a role in supporting international forestry and training in seed, cone, and regeneration insect management.

- Emerging need for seed to support diversity and habitat restoration. This introduces need to understand biology and impact of other seed pests.

- States believe there is continued need for technology development to support seed and cone work. FS is in a position to help and States do not have resources. State orchards are being mothballed. Industry looks to FS for expertise.

<u>John Taylor</u> (R-8)

- Need systemic insecticides for single tree treatment.

- Long leaf popularity is back and need seed that's adapted to dry sites. There is a regeneration problem with long leaf pine. Need data on seed and cone biology, impact, timing.

- Need hardwood seed to meet habitat restoration demands.

- South is trending toward smaller, higher productive orchards.

Jack Barry (WO/FPM Davis)

- Arranging to obtain a ground sprayer computer model from the industry sponsored Spray Drift Task Force. Harold Thistle, MTDC, is project officer.

- Negotiating partnership with New Zealand to field characterize spray and drift from orchard sprayers. Also discussion concerning cooperative field drift tests to evaluate effectiveness of tree wind breaks for spray drift attenuation.

- Cooperated with University of California and reported on spray deposition and canopy penetration of aerial sprays into a deciduous canopy (almond trees). Papers presented to international meeting of the American Society of Agricultural Engineers.

- Papers on environmental fate of pesticides in forest ecosystems published as a group in March 1993 issue of Environmental Toxicology and Chemistry - should be of interest to resource managers.

- Drift and non-target impact studies of Bt being evaluated for the 3rd year in Utah. Results of 1991 study have been presented and a manuscript accepted for publication in Envir. Tox. Chem. 1993.

III. DISCUSSION OF NATIONAL NEEDS

A. National Needs and Priorities

Initial listing of seed, cone, and regeneration insect management needs ranked by number of initial votes.

(4) Increase emphases on white bark pine to include insect identification, impact, monitoring, and control.

(4) Develop IPM strategy for managing coneworms in the Southeast. Species are *Diorytria disculsa*, *D. clarioralis*, *D. merkeli*, and *D. amatella*. Information is needed on damage/treatment thresholds, decision support systems including the RAIN weather monitoring system.

(4) Develop monitoring and decision support system for *Leptoglossus* spp. and *Dioryctria* spp. of western white pine.

(4) Identify and resolve pheromone problems for detecting *Dioryctria abietivovella* in Douglas-fir and western white pine.

(3) Develop and evaluate an environmentally acceptable method(s) to protect cones and seeds of selected single high value seed producing trees in wild stands.

(3) Develop IPM strategy for managing seedbugs in the Southeast. Species of concern are Leptoglossus cerculus and Tetyra bipunctata. Information is needed on monitoring and timing of treatment.

(3) Complete development of pheromone for control of Dioryctria spp. in the Southeast.

(2) Identify and evaluate impact of seed and cone insects on long leaf pine.

(2) Identify and evaluate impact of seed and cone insects of northern red oak flowers and acorns. Develop timing and treatment regimes to control seed and cone insects of northern red oak flowers and acorns.

(2) Evaluate impact and control methods for seed and cone insects of ponderosa pine on eastside of the Cascades in Oregon. Species of concern are Cydia piperana, C. miscitata, Dioryctria sp.; Conophthorus sp., and Megastigmus albifrons.

(2) Transfer FSCBG model to seed orchard managers for use in planning pesticide application strategies and establishing spray buffer zones.

(1) Evaluate genetic resistance and develop a hazard rating system for ponderosa pine plantation insects that impact regeneration in Oregon east of the Cascades. Insects of concern are Eucosma sonomana, Rhyacionia zozana, Pissodes terminalis and P. strobili.

(1) Evaluate genetic resistance and develop a hazard rating system for lodgepole pine plantation insects that impact regeneration in Oregon east of the Cascades.

(1) Develop a phermonally-based monitoring and control system for cone beetles in western pines. Development to include pheromone trap design, pheromone delivery, and damage thresholds.

(1) Conduct field tests of insecticides that show promise as replacements to Guthion.

(1) Register Bt as a bioinsecticide to control susceptible seed and cone insects and conduct field tests of Bt to obtain additional operational information on tank mixes, timing, application rates, and drop size.

(0) Develop a monitoring system for Douglas-fir cone gall midge, decision support system, and alternative insecticide for its control.

(0) Develop monitoring, impact, damage threshold and control system for cone and seed insects of sugar pine.

(0) Develop monitoring, impact, damage threshold and control system for cone and seed insects of Port-Orford-cedar.

(0) Evaluate feasibility of using attracticide as a cone and seed insect management tool.

B. Other Needs

Three other needs were identified that are projects within the MTDC/FPM 5-Year Plan. These are:

- Develop a computer model module for FSCBG that predicts the deposition and drift of spray for orchard air blast sprayer.
- Field test, in conjunction with FSCBG airblast sprayer model, the G-BASS System ground spray system that simulates aerial application.
- Evaluate tree wind breaks for drift attenuation around orchards.

C. Other Comments, Observations & Concerns

- The shift from timber emphasis to ecosystem management indicates a change in emphasis for the management of seed, cone, and regeneration insects and this committee.
- Urban/forest interface is impacting the way nurseries and orchards do business.
- Seed and cone projects have fared relatively well in receiving Technology Development funding. Quality of the proposal is very important.
- The term Genetic Resource Program has replaced the term Tree Improvement Program. This program is seeking assistance from seed and cone scientists. See David Hessel letter (Appendix C).
- WO/FPM wants projects (to be actions in our 5-Year Plan) to be specific. That's how our plan will be.

- By intent there is lack of FIDR pesticide research; however FIDR researchers can do biorational insecticides research.

- FPM cannot do research; therefore in proposal provide statement that separates the proposed work from research.

- There is confusion on propriety of FPM teaming with Research on jointFprojects because of separate funding allocations. Nothing new here but some perceive this as a potential problem.

- State cooperators are perceiving decreasing support for this committee by WO. We need to point out that this isn't the situation and show them results of Technology Development Program.

- Concern expressed over seeming lack of coordination of eco-data and permanent plot collection and databases. What about format, standardization, programs, etc.; such would help?

- Forest health is influenced by all "functions" in the ecosystem from soil microbes to the atmosphere surrounding the ecosystem.

- Placerville (CA) Nursery is experiencing increasing "demand for "non-traditional" seed to include native grasses, bitterbrush, ceanothus, madrone, blue elderberry, and manzanita.

IV. 5-YEAR TACTICAL PLAN DISCUSSION

The Director, Washington Office has requested each of the national steering committees to prepare a 5-Year Tactical Plan. The primary purpose of the Plan is to acutely focus on what needs to be done to advance forest health within the committee's realm of activity.

At the Placerville meeting we decided upon a format for the Plan and 6 Goals from the 20 needs listed in paragraphs III, A above. The format considers Categories (does the goal fit into one of the Categories?); Goals; Rationale; Actions; and Time Schedule.

CATEGORY for advancing seed, cone, and regeneration technology program.

- Basic biological and taxonomical information
- Impact
- Monitoring
- IPM situation/decision models
- Control strategies
- Technology transfer and training

GOALS

The seven highest priority projects/goals we identified are listed below. We sorted these from 20 needs identified at the beginning of the meeting. Goal 1 is the highest priority, descending to Goal 6 the lowest. The needs were rephrased in terms of goal statements as follows:

1. Regeneration insects of white bark pine have been identified, monitoring and impact methods developed, and potential control strategies have been identified. (Jed Dewey)

2. IPM strategies for southeastern coneworms have been developed. (Larry Barber)

3. Pheromones for Dioryctria spp. has been developed and available for operational use in the southeast. (Larry Barber)

4. Monitoring and control systems for western white pine seed bug and coneworm have been developed and are available for use. (Roger Sandquist)

5. Single tree treatment methods to control seed and cone loss in wild stands have been developed and demonstrated. (Nancy Rappaport)

6. Effective pheromone detection systems for Dioryctria spp. in Douglas-fir have been demonstrated. (Nancy Rappaport)

We assigned one person to each goal as indicated to coordinate preparation of the rationale, and actions.

RATIONALE

This statement discusses the problem or need, why it's important, what is known, what needs to be done, and probability of success.

ACTIONS

Next it would be most helpful if each of you would list an action item(s) for each of the 5 years that will lead us to the end product - eg., a monitoring system or treatment method, whatever our goal statement indicates.

STRATEGIES

Strategies (sub-actions) as needed will be developed to support actions.

TIME SCHEDULE

There will, therefore, be at least one major action per year. If there are strategies which in most cases there will be, we can add more detail to each year's schedule.

V. SUMMARY

The National Steering Committee for Management of Seed, Cone, and Regeneration Insects met at Placerville, CA, June 29-July 1, 1993 hosted by Nancy Rappaport, Pacific Southwest Station. The primary purpose of the meeting was to identify and prioritize FPM Technology Development needs and to develop the format and goals of a 5-Year Tactical Plan. Other needs, concerns, and issues were discussed and noted. There were two days of indoor meetings and a field trip to the Placerville Nursery and Forest Hill Seed Orchard. This was a very productive meeting with meeting and field trip objectives clearly realized. We identified the 6 most important goals for our 5-Year Tactical Plan. We discussed time and location of the next meeting and it was unanimously agreed that the end of June meets the schedule of members present. R-8 graciously offered to host the 1994 meeting. It was decided, however, to have the meeting in the North Central US to increase probability of Canadian participation and to tour North Central orchards. Steve Katovich, NA (St. Paul) subsequently offered to host the meeting and field trip at Rhinelander, WI, June 28-30, 1994. Thanks to all for a great meeting.

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Appendix A

Member Reports

Larry Barber (R-8)

COMPARISON OF GROUND AND AERIAL APPLICATION SPRAY DRIFT

ON THE UNION CAMP CORPORATION SOUTHERN STATES LOBLOLLY PINE SEED

ORCHARD IN CLAXTON, GA

AUGUST 20-23, 1991

L. R. Barber [1/] and A. Mangini [2/]

Abstract.--Ground application of a spray solution containing Rhodamine WT and water applied with a FMC 757 Speed Sprayer resulted in less drift than did the application from a Cessna Ag Truck fixed wing aircraft. Spray drift was at detectable levels in small amounts to 1000 feet for the aircraft and 250 feet for the ground sprayer directly downwind of the spray block .

Keywords: Loblolly pine, Pinus taeda L, Rhodamine WT, Bullseye, Cessna Ag Truck, drift.

INTRODUCTION

The production of seed is vital to seed orchard managers and the limiting factor reducing production is damage from a variety of seed and cone insects. Various control strategies have been developed in the past to address the damage from insect pests. Presently, most orchard managers use repeated applications of a liquid insecticide applied either by ground sprayer or aircraft. The insecticide most commonly used is azinphos-methy (Guthion) applied via aircraft. In the past two years many orchard managers have switched to Foray 48B, a Bacillus thuringiensis (Bt) formulation.

The USDA Forest Service has focused on improving pesticide application deposition while minimizing off-site spray drift. All groups concerned with the application of pesticides to southern pine seed orchards recognize the importance of minimizing pesticide drift from the orchard to adjoining land or water areas. In 1980 Jack Barry (Barry et al. 1980, and Barry et al. 1982) first determined the feasibility of aerially applying pesticides to southern pine seed orchards on the State of Florida, Withlacoochee Seed Orchard near Brooksville, FL. Drift in this study was confined within 133 meters downwind of the spray source.

In the Withlacoochee Trials both a Hughes 500C and a Stearman aircraft were used. The volume median diameter (VMD) of the five gallon per acre spray was 525 μm for the Hughes and 524 μm

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[2] Entomologist, USDA, Forest Service, Forest Pest Management, Alexandria, LA.

Presented to SFTIWC June 1993

for the Stearman. The ratio of deposition 15 meters downwind from the orchard edge to within-orchard deposition ranged from 0.06 to 0.49 (J. W. Barry et al. 1983). Wind speed ranged up to 2.8
meters per second. In an additional test over open field conditions, spray deposit ratios at 133 meters were 0.002 with deposits of 1 oz/acre. Wind ranged from 2.7 to 5.8 meters per second. From this report Barry concluded that drift deposits 60 meters downwind of seed orchards in flat terrain is about 8 percent of the amount deposited in the treatment area and can be expected to 100 meters. They also concluded that large amounts of spray are deposited with a 15 meter zone surrounding orchards.

In 1991 a study was undertaken to compare ground and aerial application on the Union Camp Southern States loblolly pine seed orchard. This study evaluated deposition within the tree canopy, forest floor and downwind (Barber and Mangini 1993).

MATERIALS AND METHODS

Scope

This was a cooperative project between the USDA Forest Service and Union Camp Corporation conducted August 20-22, 1991. There were two trials each morning that compared ground and aerial application.

Site Description

The orchard is located 4.5 mi south and west of Claxton, Ga. The orchard has tree spacing of 22 x 22 ft (6.7m) . The test site was the 8.9 acre Alabama rust resistant loblolly pine, Pinus taeda L., area of the orchard.

Meteorological Measurement

Meteorological conditions were measured with: 1) a Handar 540A on a 22 ft (6.7 m) tower located near the center of the spray block, 2) another Handar 540A on a 55 foot (16.8 m) tower located 600 ft (182.9 m) northeast of the spray block and 3) a Forest Technology System F11 on a 6 ft (1.8 m) tower located 300 ft (91.4 m) east of the spray block in an open field.

Application

The aircraft sprayed a mixture of Bullseye dye and water and the ground sprayer applied a mixture of Rhodamine WT dye and water. The aircraft application was 1.19 gal/acre (4.5 l) while the ground sprayer application rate was 2.88 gal/acre (10.9 l) for days 1 and 2 and 5.76 gal/acre (21.8 l) for day 3. The aircraft was a Cessna Ag truck Model 185 flying at 110 mi/h (177 km). The ground sprayer was a FMC 757 Speed Sprayer traveling at 2.5 mi/h (4.0 km).

Drift Sampling

During each spray application, drift lines were established beginning 50 ft (15.3 m) within the orchard and extending out from the spray block downwind in 50 ft increments. Drift line samplers were Kromekote cards 4 x 5 in (10.2 x 12.7 cm).

Stain Deposit Measurement

Stains on Kromekote cards were measured by placing each card under a dissecting microscope fitted with a graduated measuring reticule. On each card a minimum of 50 stains were counted and the area observed did not exceed 16 cm^2. Spray stain numbers and sizes were analyzed using the Automated Spot Counting and Sizing program (ASCAS, Continuum Dynamics) to convert drop counts into spray volumes. The spray volume and numbers of drops/cm^2 were adjusted for the ground sprayer application rate to equal the aircraft application rate. When equivalent deposition is used it is noted.

RESULTS

Characterization

Volume median diameter (VMD) for the aircraft was 196, 136, and 127 microns for days 1, 2, and 3 respectively. The effective swath width (eight drop/cm^2 minimum deposition) for days 1, 2, and 3 were calculated to be 90, 110, and 100 ft respectively. No swath width was determined for the ground sprayer, however, the VMD for day 3 was 202 microns.

Meteorological Conditions

On day 1 maximum wind ranged from 5.5 mi/h to 7.2 mi/h and was out of the west-southwest with temperatures in the lower eighties with relative humidities from 69.5 to 89 percent. During day 2 the wind was from the west at less than 2 mi/h. On day 3 wind was 2.6 mi/h from the north-northwest. The temperature ranged from 72.4 F° to 82.3 F° with the relative humidity from 68.7 to 90 percent.

Spray Drift

Day 1

Deposition on the ground within the orchard and at the orchard edge for both the aircraft and ground sprayer ranged from 44.9 to 46.5 fl oz/acre (tables 1 and 2). Aircraft deposition dropped off rapidly with increased distance from the orchard edge and at 150 feet only 6.26 fl oz/acre were detected. Here a ratio of only 0.2:1 was found as compared to within the orchard (table 3). This is 20 percent deposition compared to within the orchard . At 300 feet 0.15 fl oz/acre were detected or 0.1 percent of the deposition within the orchard. Ground sprayer deposition 150 feet

outside the orchard was 3.95 fl oz/acre or 11 percent of within orchard deposition. At 300 feet deposition was 0.1 fl oz/acre or 0.1 percent of within orchard deposition.
Day 2

Aircraft deposition directly downwind of the spray block at 150 feet from the orchard edge was 6.89 fl oz/acre or 18 percent of the deposition within the orchard. Ground sprayer deposition however was 0.38 fl oz/acre or 3 percent of the within orchard deposition. All cards beyond 150 feet received spray deposition but were wet and unreadable.

Day 3

Spray deposition from the aircraft at 150 feet from the orchard edge was 25.08 fl oz/acre or 111 percent of that found within the orchard. At 300 feet the deposition fell to 4.19 fl oz/acre and at 400 feet was 0.78. This represented 5 and 1 percent respectively of the deposition within the orchard. Aircraft deposition was 0.02 fl oz/acre at 1000 feet. Ground sprayer deposition at 150 ft was 0.17 fl oz/acre and 0.09 fl oz/acre at 250 ft with no further deposition detected to 1000 feet.

Table 1 - Ground spray deposition on drift line samplers - Claxton Spray Trials, 1991

Drift line 1

Card position	Day 1 Fluid ounces/acre	Day 2 Fluid ounces/acre	Day 3 Fluid ounces/acre
-50.00	44.90	6.19	31.04
0.00	29.75	20.18	17.33
50.00	12.18	56.10	26.55
100.00	21.14	4.20	1.97
150.00	3.95	0.38	0.17
200.00	0.73	wc	0.17
250.00	1.10	wc	0.09
300.00	0.01	wc	0.00

Table 2 - Aircraft spray deposition on drift line samplers - Claxton Spray Trials, 1991.

Drift line 1

Card position	Day 1 Fluid ounces/acre	Day 2 Fluid ounces/acre	Day 3 Fluid ounces/acre
-50.00	17.22	76.56	43.72
0.00	46.51	0.98	1.41
50.00	31.21	36.98	31.09
100.00	17.27	48.91	33.81
150.00	6.28	6.89	25.08
200.00	2.63	wc	11.57
250.00	5.59	wc	4.19

300.00	0.15	wc	4.19
350.00	NA	NA	1.07
400.00	NA	NA	0.78
450.00	NA	NA	0.30
500.00	NA	NA	0.07
550.00	NA	NA	0.20
600.00	NA	NA	0.01
650.00	NA	NA	0.11
700.00	NA	NA	0.17
750.00	NA	NA	0.00
800.00	NA	NA	0.16
850.00	NA	NA	0.01
900.00	NA	NA	0.01
950.00	NA	NA	0.01
1,000.00	NA	NA	0.02

Table 3 - Drift deposit ratios from aerial and ground tank mixes comparing deposition within the orchard to drift sites outside the orchard - Claxton Spray Trials, 1991

Drift line 1

	Day 1		Day 2		Day 3	
Card position	Ground sprayer	Aircraft	Ground sprayer	Aircraft	Ground sprayer	Aircraft
50.00	0.33	0.98	4.25	0.95	1.10	1.38
100.00	0.58	0.54	0.32	1.26	0.08	1.50
150.00	0.11	0.20	0.03	0.18	0.01	1.11
200.00	0.02	0.08	wc	wc	0.01	0.51
250.00	0.03	0.18	wc	wc	0.04	0.19
300.00	0.0002	0.001	wc	wc	0.00	0.05
350.00	NA	NA	NA	NA	0.00	0.03
400.00	NA	NA	NA	NA	0.00	0.01
450.00	NA	NA	NA	NA	0.00	0.003
500.00	NA	NA	NA	NA	0.00	0.01
550.00	NA	NA	NA	NA	0.00	0.0004
600.00	NA	NA	NA	NA	0.00	0.005
650.00	NA	NA	NA	NA	0.00	0.01
700.00	NA	NA	NA	NA	0.00	0.00
750.00	NA	NA	NA	NA	0.00	0.01
800.00	NA	NA	NA	NA	0.00	0.00
850.00	NA	NA	NA	NA	0.00	0.0004
900.00	NA	NA	NA	NA	0.00	0.0004
950.00	NA	NA	NA	NA	0.00	0.0004
1,000.00	NA	NA	NA	NA	0.00	0.0009

DISCUSSION

Spray drift downwind and off-site from a seed orchard spray block appears to be more likely with aerial application compared with ground based sprays where small droplet sizes are used and when comparing equal amounts of spray solution per acre. Under normal orchard aerial spray conditions using the pesticide Guthion, the VMD is usually greater than 350 microns (Barber and Fatzinger 1987). In this test the VMD ranged between 127 and 196 microns. Many orchard managers are currently using Foray 48B applied at 1 gal/acre with VMD's similar to this study. In these cases drift beyond 300 feet from the orchard edge may be expected. This drift may not pose a significant problem on orchards as most orchards have a pollen buffer zone around the orchard. All Federal orchards have a 400 ft buffer to minimize pollen from entering the orchard. Potential drift from the orchard would be deposited on this buffer strip. The resulting off-site deposition in this study would have been less than 1 fl oz/acre beyond 400 feet of the orchard edge. Using larger droplet sizes would also reduce drift from the orchard.

The ground sprayer solution in this study did not drift far from the orchard but remained on site. On day three, deposits downwind of the orchard were detected to only 250 feet with none found after that point. This compares to aircraft deposition to 1000 feet. Ground sprayers however apply from 10 to 100 times more volume per acre than aircraft under orchard conditions and the resulting spray would result in considerable deposition within the orchard. Unfortunately, this deposition is found on the ground and on the lower branches (Barber and Mangini 1993) while the cone crop is found on the upper half of the crown. Previous work has shown more drift downwind when using ground sprayers (Ware et al. 1969). Possibly this is because the previous work was in open fields. This study was in a mature seed orchard. Under these conditions most of the spray material was deposited on the bottom branches and did not reach the upper crowns in quantities to move above the trees where drift could occur. In comparison the aircraft released its solution 15 to 20 ft above the trees.

CONCLUSIONS

Off-site aerial spray drift using droplet sizes less then 200 microns may result in spray deposition to 1000 feet, however, the majority of the off-site deposition was contained to within 300 ft of the orchard edge. This deposition would fall within a pollen management buffer strip which is located on most orchards. Because most orchard managers apply Guthion at 10 gallons per acre with a VMD of 350 microns or greater, less drift would be expected under these operational parameters.

LITERATURE CITED

Barber,L.R., and C.W.Fatzinger. 1987. Aerial application methods used in southern pine seed orchards. Presented to the 1987 Symposium on Aerial Application of Pesticides in Forestry at the Associate Committee on Agricultural and Forestry Aviation of the National Research Council of Canada and The Canadian Forestry Service meeting. Ottawa

Barber,L.R. and A.Mangini. 1993. A Comparison of Ground and Aerial Application at the Union Camp Southern States Loblolly Pine Seed Orchard Claxton, GA August 20-22, 1991. Forest Pest Management Asheville Field Office Report # 93-1-04. Asheville, NC, USDA For. Serv. 98 pp.

Barry,J.W., R.B.Ekblad, and L.R.Barber. 1980. Aerial application to coniferous seed orchards. Presented to the 1980 ASAE/NAAA jointly sponsored technical session on agricultural aviation research at the National Agricultural Aviation Association annual meeting, Las Vegas, Nevada.

Barry,J.W., R.B.Ekbald, P.A.Kenney, and L.R.Barber. 1983. Drift from aerial application to coniferous seed orchards. American Society of Agricultural Engineers and National Agricultural Aviation Association paper No. AA-83-003. Reno, NV., U. S. Dep. Agric. For. Serv. 8 pp.

Barry,J.W., P.A.Kenney, L.R.Barber, R.B.Ekblad, J.Dumbauld, J.E.Rafferfy, H.W.Flake, and N.A.Overgaard. 1982. Aerial Application to Southern Pine Seed Orchards Data Report of the Withlacoochee Trials. U. S. Dep. Agric. For. Serv., Forest Pest Management, Asheville Field Office Report #82-1-23, May 1982.

Ware, G.W., E.J.Apple, W.P.Cahill, P.D.Gerhardt, and K.R.Frost. 1969. Pesticide drift II. Mist-blower vs. aerial application of spray. J.Econ. Entol. 62:4, pp 844-846.

Disclaimer

Caution: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

Scott Cameron
(Texas)

TEXAS FOREST SERVICE

The Texas A&M University System

Forest Pest Control
(409) 639-8170
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P.O. Box 310
Lufkin, Texas 75902-0310

5.5B

July 29, 1992

John W. Barry
USDA Forest Service
2121 C Second Street
Davis, CA 95616

Dear Jack:

I am writing in response to your letter of May 1, 1992, regarding technology development needs and the next meeting place and time for the National Steering Committee for Management of Seed, Cone, and Regeneration Insects.

I would prefer having the next meeting in the Northwest as originally planned. However, since the meeting is scheduled "prior to the 1993 field season," another possibility would be to have a shorter Steering Committee meeting during the week of the Western Forest Insect Work Conference in California. This would allow several of the Steering Committee members from other regions to attend the WFIWC and would save on travel funds for those who otherwise would have to attend two separate meetings. I would not mind arriving a day early, staying an extra day, or meeting during the evening, if necessary.

If it is not too late, I would like to add a couple of items to the list of "National Needs" and "Recommendations" for Technology Development projects which were developed at the June 1991 meeting in Boone, NC.

First, I have a couple of questions and comments regarding the "Recommendations." Under item 1, it is suggested that spray deposition and drift data from ground applications are needed for "model prediction of ground sprayer performance." Does this mean that a module for predicting deposition and drift from ground sprayers will be added to the FSCBG model? I hope so, because this would be very useful, especially for comparing deposition and drift from ground and aerial applications. Has any progress been made with facilitating EPA registrations for the use of pheromones and biological pesticides to control insects? This is a very important objective if we are ever going to add safer tools to our pest management arsenal. I would like to add my support to these two initiatives.

Please add the following items to the "National Needs" list: **"Develop, evaluate, and utilize a ground-based sprayer for simulating aerial sprays"** and **"Implement IPM practices in several southern pine seed orchards"** (see the enclosed list). A ground-based sprayer capable of applying spray deposits, on trees in the field, similar to those of aerial spray applications could be used in many of the other projects included in the "National Needs" (highlighted in bold type in the enclosed list). Without such a sprayer, several of the proposed field studies will not be conducted. A technology development project to implement IPM practices in southern pine seed orchards would promote the use of management practices

aimed at improving and reducing pesticide applications and promoting the use of "safer" pesticides.

A cooperative Technology Development project entitled "simulation of aerial sprays with ground equipment" is currently in progress. Alex Mangini, Larry Barber, Bob Sanderson and I are co-investigators in this project. I have enclosed a brief summary of accomplishments to date for this multifaceted project for your information.

The spray system we have built is capable of spaying a variety of droplet spectra and volumes propelled toward the target by hydraulically driven fans. The spray system has been used successfully to apply one gallon per acre at a VMD of near 100 in an insecticide timing test for Nantucket pine tip moth control on 5 to 8 ft trees in a loblolly pine plantation. Jim McConnell and Jerry Edwards, USDA Forest Service, Regional Office in Atlanta visited Texas this summer to inspect and make suggestions for our sprayer. They were very helpful and enthusiastic about progress to date. Currently, we are at the critical stage of building and testing a spray boom which will spray seed orchard trees up to 25 ft tall.

This technology development project also has generated considerable data on spray deposition in and around pine seed orchards which will be used to: 1) further characterize aerial spray deposits in pine seed orchards under a variety of conditions, 2) develop fluorometric spray deposition techniques and 3) field test the FSCBG aerial spray deposition model. This project also is facilitating the technology transfer process for the FSCBG model. Seed orchard managers are being exposed to the model validation process and are anxious to put the model in operation.

At least one additional year (March 1993 - February 1994) is needed to fully develop and test the ground-based aerial spray simulator for spraying trees in pine seed orchards. With additional funding, the sprayer possibly could be used to conduct tests on biological controls such as Foray, pheromone application techniques, improved application efficiency, field testing of insecticide application timing, and evaluating new insecticides for managing seed, cone, and regeneration insects. Seed orchard managers are keenly interested in this project since they are anxious to utilize the sprayer for conducting efficacy tests and also for operational use in treating individual trees with valuable controlled crosses. It has been suggested that Missoula Technology Development Center eventually may become involved in developing a more carefully engineered aerial spray simulator based on the models and experience gained from this project.

Your past and future support of this project is greatly appreciated.

Sincerely,

Scott

R. Scott Cameron
Entomologist III

cc: Alex Mangini
Larry Barber

NATIONAL NEEDS*

1. **Develop and evaluate non-chemical control alternatives to include burning, behavioral chemicals, and biological control methods to manage seed, cone and regeneration insects**

2a. **Develop timing mechanisms for initiating insect control activities**

2b. Develop monitoring and prediction systems for: *Dioryctria* spp., cone beetles, white pine cone borer and other *Eucosma* spp., seed bugs, and Douglas-fir cone gall midge

3. **Develop, evaluate, and utilize a ground-based sprayer for simulating aerial sprays**

4. **Identify and evaluate new insecticides for managing seed, cone, and regeneration insects**

5a. **Conduct field studies for reduced rates of the insecticide Guthion and other insecticides**

5b. **Identify, evaluate and develop pheromone application equipment and techniques**

6. Determine impact and damage thresholds for: 1) seed bugs, 2) cone and seed insects of western white pine, ponderosa pine, and white fir, 3) complex of regeneration insects in ponderosa pine and lodgepole pine, and 4) western pine tip moth

7. **Evaluate and validate coneworm spray timing model**

8. **Improve application efficiency to seed orchards and wild collection sites. (Application efficiency is important for National Needs numbers 1, 3, and 4)**

9. Evaluate IPM simulation models for southern pines

10. **Implement IPM practices in several southern pine seed orchards: 1) install weather monitoring systems, 2) record and print out coneworm moth pheromone trap catch data, 3) spray for seed bugs based on knock down sample data, time coneworm sprays according to pheromone trap thresholds and degree-day models, and 5) develop and use IPM simulation model to assist with decision making**

* Items in **bold print** are projects for which a ground-based aerial spray simulator would be useful or essential; new items are in **bold type and underlined**.

SIMULATION OF AERIAL INSECTICIDE SPRAYS WITH GROUND EQUIPMENT

COOPERATORS:

Dr. Alex Mangini, USDA Forest Service, FPM, Alexandria, LA
Mr. Larry Barber, USDA Forest Service, FPM, Asheville, NC
Dr. Scott Cameron, Texas Forest Service, Lufkin, TX
Dr. Robert Sanderson, New Mexico State University, Las Cruces, NM

BACKGROUND:

Most operational insecticide applications in southern pine seed orchards are performed with aerial equipment using low volume sprays. High priority has been placed on the development of improved application techniques and new and safer pesticides for use in forest seed orchards. Replicated tests of aerially applied insecticides are nearly impossible to conduct in forest seed orchards due to acreage limitations. Therefore, a technique is needed for applying simulated aerial sprays on individual trees to enable researchers to conduct replicated tests of new pesticide products.

OBJECTIVES:

The objectives of this project are: 1) to develop a ground-based sprayer (GBS) which is capable of simulating aerial spray deposition on individual trees, 2) to develop a protocol for measuring spray deposition on tree foliage using fluorometric analysis, 3) to characterize deposition from actual aerial spray applications in pine seed orchards, 4) to compare actual aerial spray deposition with FSCBG aerial spray deposition model predictions, 5) to utilize the GBS to conduct field efficacy tests against the Nantucket pine tip moth and pine seed bugs.

PROGRESS REPORT:

Accomplishments to date include: 1) development of a spray system attached to a John Deere tractor utilizing a Micronair AU7100 nozzle, 2) characterization of swath widths, spray deposition (VMD and drops/cm^2) and wind speeds at several distances from the nozzle for each of three RPM and three fan blade settings under controlled environmental conditions, 3) utilization of the GBS to conduct an efficacy and spray timing test with Foray® 48B, Asana® XL, and Cygon® in a pine plantation to control the Nantucket pine tip moth (*Rhyacionia frustrana*), and 4) characterization of aerial spray deposits (using an image analyzer and computer software to measure numbers and sizes of droplets on spray cards and calculate volumes, and using fluorometric analysis for measuring deposits on foliage) in three seed orchards with a variety of spray equipment configurations and application rates. Additional accomplishments expected during the next seven months include: 1) developing and testing the GBS for simulating aerial spray deposits on 15-20 ft seed orchard trees, 2) utilization of the GBS for conducting an efficacy test on pine seed bugs, and 3) comparing actual spray deposition data with FSCBG aerial spray deposition model predictions.

Jed Dewey (R-1)

CONE & SEED/PLANTATION INSECT INFO/NEEDS REGION 1
(6/21/93)

FS Seed Orchards Producing Cones

Western White Pine	Douglas-fir	Ponderosa Pine
CDA Nursery	Dry Creek (just starting)	Russell Bar
Lone Mountain		
Grouse Creek		
Priest River		

Current Pests

*Leptoglossus occidentalis***
*Dioryctria abietivorella***
Conophthorus ponderosae
Eucosma rescissoriana

** currently most important

Research Needs

1. Monitoring methods

We are in dire need of some good monitoring methods for all pests. Three different pheromone blends for Dioryctria were tried in 1991 and no moths were caught even though damage was common in the orchards. A black light trap has also been tried unsuccessfully to catch Dioryctria.

Current monitoring methods consist of direct observation which is extremely time consuming and not effective in determining timing of insecticide treatment against Dioryctria because by the time we see evidence of damage, it is too late to treat. Direct observation is currently used for determining the need and timing for control of Leptoglossus. Direct observation is nearly impossible to do from the ground, even with binoculars. In order to be accurate, we observe from a bucket truck whenever possible. An egg mass survey was tried for Leptoglossus without success in finding eggs with a reasonable sized sample.

2. Alternative pesticides

The only current insecticide treatment is the use of Pounce (permethrin) at the CDA nursery for Leptoglossus control. This has been done for several years and we now have a problem with scale insects. We need alternatives to Pounce for Leptoglossus control.

3. Biological controls

Biological controls are usually more accepted by the public and less disruptive to natural enemies of the pests. The CDA nursery manager is very desirous of having alternatives to pesticides.

We're interested in being involved with any pheromone work for the above mentioned pests, or experimenting with new insecticides for Legtoglossus, or any other type of monitoring method next year. More seed orchards are coming into production in the Region our needs will increase in the future.

PLANTATIONS

The most important pest problem in plantations, that we're currently involved with is a tip moths at the Lenore ponderosa pine test plantation. Tip moths were killing up to 10% of the terminal buds of 2 yr. old trees in a growth selection trial. Four different pheromone baits were placed in sticky traps to determine the species of tip moth involved, and to determine the timing of insectide treatment. The species was determined to be *Rhyacionia zozana* and/or *R. buskana*. The plantation was treated this spring with carbaryl a week after the first moths were caught and a second time two weeks later. We have not yet done a post spray assessment but the plantation manager hasn't seen much damage this year.

Problem Statement for a Whitebark Pine Cone and Seed Protection Thechnology Development Project

Only recently has whitebark pine, Pinus albicaulis, been recognized as a key component of high elevation ecosystems throughout much of the West. This unique species plays an important role in the survival and distribution of such wildlife species as the grizzly bear and the Clarks nutcracker, by providing a high protien food source with its cones and seeds. Research has just documented the rapid decline of this important specie in western Montana and other areas (Keane and Arno, 1993) due primarily to the introduced white pine blister rust fungus and periodic outbreaks of the mtn. pine beetle. A need is being recognized to promote natural regeneration, and supplement it artificially, especially with rust resistant nursery stock.

To date virtually nothing is known about the role cone and seed feeding insects play on the regeneration of this species. Prior to developing treatments to protect cones and seeds from insect depredations, it has to be determined what insect complex is affecting seed production, the extent of their impact, and whether protection is needed.

This technology development project would be a cooperative effort with FPM in R-1 and the PSW Station addressing these questions.

Keane, Robert E. and Stephen F. Arno.1993. Rapid decline of whitebark pine in western Montana: evidence from 20-year remeasurements. Western Journal of Applied Forestry, Vol.8, Number 2.

[illegible]

Only [illegible] high elevation [illegible]

[illegible]

The [illegible] only [illegible] that the [illegible] development [illegible] forests and stands from insects [illegible] the extent [illegible] whether protection is needed.

This technology development project would [illegible] cooperative effort with FPM in R-1 and [illegible] address these questions.

Keane, Robert E. and Stephen F. Arno. [illegible] Rapid decline of whitebark pine in western Montana: evidence from 20-year remeasurements. [illegible] Journal of Applied Forestry, Vol. 8, Number 2.

Tom Hofacker (WO)

Pest Alert

United States
Department of
Agriculture

Forest Service

Northeastern Area

NA-TP-05-93

New Introduction - Common Pine Shoot Beetle, *Tomicus piniperda* (L.)

The common (or larger) pine shoot beetle, *Tomicus* (= *Blastophagus*) *piniperda* (L.), was discovered near Cleveland, Ohio in July 1992. As of this writing, it is now in six states: Illinois, Indiana, Michigan, New York, Ohio, and Pennsylvania. Adults of the common pine shoot beetle are cylindrical and range from 3 to 5 mm in length (about the size of a match head). Their head and thorax are shiny black while the wing covers are reddish-brown to black. Eggs are 1 mm long, oval, smooth, and shiny white. Larvae are legless, slightly curved, have a white body and brown head, and can reach 1/4 inch (5 mm) in length when fully grown.

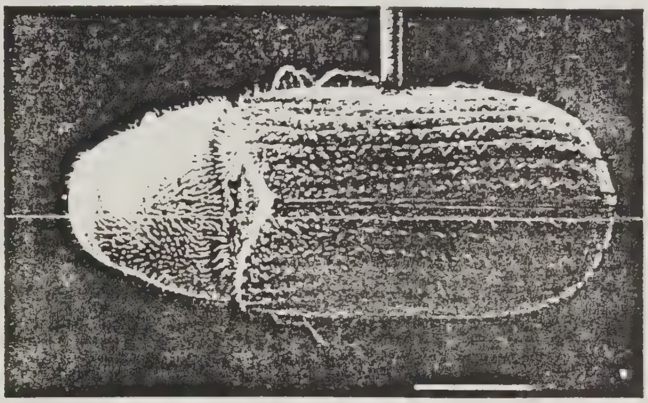

Figure 1. Adult Beetle (*Scale line = 1 mm*)

Life History

Tomicus piniperda completes one generation per year throughout its native range of Europe and Asia. Overwintering adults initiate flight on the first warm (50-54° F) days of spring which probably occurs in February or March in the Lake States in the northeastern United States. Adults quickly colonize either recently cut pine stumps, logs, or, at times, infest the trunks of severely weakened trees. If necessary, adults can fly 1/2 mile (1 km) or more in search of host material. Pine is the principal host tree. When populations are high, adults may breed in spruce, fir, and larch logs that occur in stands mixed with pine. Various species of blue stain fungi are associated with this bark beetle.

Figure 2. Mined shoots of Scotch Pine. (Arrow indicates entrance gallery)

Adults use host volatiles such as alpha-pinene to locate suitable host material for breeding. *T. piniperda* does not appear to produce an aggregation pheromone (sex attractant). Females initiate gallery systems and soon one male joins each female. After mating, females construct individual vertical egg galleries within the inner bark and outer sapwood. Egg galleries extend 4 to 10 inches (10 - 25 cm) in length. Females lay eggs singly in niches that are cut into both sides of the egg gallery. After hatching, larvae construct horizontal feeding galleries that are 1.5 to 3.5 inches (4 - 9 cm) long. Most larvae complete development, pupate, and transform to adults in May and June.

The newly formed adult's tunnel through the outer bark, creating circular exit holes about 2mm in diameter. They then fly to the crowns of living, healthy pine trees of all ages, but prefer the taller trees in any particular area. Adults feed primarily inside lateral shoots, mostly in the upper half of the crown from May through October. During this period of maturation-feeding, each adult may destroy 1 to 6 shoots. Scotch pine is preferred, but other pine species have been infested in the Lake States including Austrian pine, eastern white pine, red pine, and jack pine.

Adults usually enter shoots in the one-year old or current year's growth. Normally, one beetle infests each shoot. They tunnel into the center and bore outwards, hollowing out 1 to 4 inches of

the shoot. After several weeks, adults often emerge and enter other shoots. Infested shoots generally bend near the point where the beetles entered, turn yellow to red, eventually break off, and fall to the ground.

In the Lake States, adults exit twigs soon after the first frosts in October and November and enter the thick bark at the base of pine trees to spend the winter. Adults typically overwinter at the base of the same pine tree that supported their maturation feeding. A few beetles may pass the winter inside twigs in the crown.

Damage

The most severe damage caused by *T. piniperda* is the destruction of shoots during maturation feeding. When shoot feeding is severe, tree height and diameter growth are reduced.

Generally, the reproduction phase of this beetle in pine stumps and slash causes little economic damage.

Figure 3. Damaged shoots on Scotch Pine.

However, in China and Poland, *T. piniperda* has attacked and killed apparently healthy pine trees.

For more information:

Prepared by
Bob Haack USDA FS NCFES
Dan Kucera USDA FS NA

Technical Advisor
Steven Passoa USDA APHIS/PPQ

Northeastern Region

USDA Forest Service
Northeastern Area
State and Private Forestry
Forest Health Protection

Chris Niwa (PNW)

MESSAGE DISPLAY FOR BARRY, JACK

To   Barry, Jack:R05H

From: Christine G. Niwa:S26L05A
Postmark: Jun 08,93 4:19 PM   Delivered: Jun 08,93 4:17 PM

Subject: Reply to a reply: Placerville Meeting

Reply text:
From: Christine G. Niwa:S26L05A
Date: Jun 08,93 4:19 PM
Hello Jack. Except for the Dioryctria mating disruption work I am cooperating with DeBarr on (which I'm sure he will cover), the only other seed orchard study I have going this year is some work with Leptoglossis (looking at seasonal impacts and possibly a monitoring technique). Concerning the strategic plan, I don't think much has changed since we discussed priorities in NC. I still believe that research emphasis should be on biorational control methods and on monitoring. CGN

Preceding message:
From: Barry, Jack:R05H
Date: Jun 02,93 10:32 AM
DO YOU HAVE ANY INPUT TO THE COMMITTEE?

From: Christine G. Niwa:S26L05A
Date: Jun 01,93 2:02 PM
I will not be able to attend. CGN

From: Nancy Whitmire:R05H acting for Barry, Jack
Date: Jun 01,93 10:23 AM
See contents.

------========X=======-------

United States Department of Agriculture
Forest Service
Pacific Northwest Research Station
Forestry Sciences Laboratory
3200 S.W. Jefferson Way
Corvallis, Oregon 97331

August 19, 1993

Jack Barry
USDA Forest Service
2121C Second St.
Davis, CA 95616

Dear Jack,

After considerable thought, I felt it was more appropriate to respond to the recent Cone, Seed, and Regeneration Steering Committee report and 5-year Tactical Plan directly by letter, rather than as a paragraph within the report.

Neither the committee report or the tactical plan represent a balanced view of national cone, seed and regeneration needs. This is in large part due to the composition of the committee, which has not changed since the addition of regeneration responsibilities in 1991. Committee members were selected for their expertise in cone and seed management or research, and while a few have interests in both seed production and young stands, most are not active in regeneration problems.

With the implementation of ecosystem management, numerous complex questions concerning the regeneration of young forests need to be addressed. For instance, in the West large acreages of Douglas-fir are scheduled to be converted back to Ponderosa pine and Western larch stands through the use of various silvicultural practices including prescribed burning. The effect of this conversion on known pests (eg. Western pine shoot borer and tip moths) as well on potential pest species is largely unknown. In addition, the impact of various management practices on general arthropod biodiversity and on specific functional groups (eg. predators and detritovores) needs to be investigated. Within the concept of ecosystem management, forest service entomologists, both in research and management must recognize the many roles of insects beyond pest status--as participants in nutrient cycling, food for wildlife species, gap producing agents, etc.

My recommendations would be to: 1) Include more managers and researchers working in the field of regeneration. Some possible researchers are Wayne Berisford (U. of Georgia), Lonne Sower (PNW, Corvallis), and Darrell Ross (Oregon State Univ.). 2) Hold the meeting in the fall or winter to improve attendance. This is particularly important with the inclusion of regeneration insects, as spring and early summer are when many species become active.

In addition to my general comments, I will state my specific concerns about Goal 6 "Effective pheromone detection systems for *Dioryctria* spp. in Douglas-fir have been demonstrated". In the late 1980's, PNW conducted about a 5-year effort to identify the sex pheromone of *Dioryctria abietivorella*, the fir coneworm. This work included a large rearing program and the efforts of three scientists (Gary Daterman, Lonne Sower and Charles Sartwell) who are well known for their pheromone chemistry work with the Douglas-fir tussock moth, Western pine shoot borer, *Rhyacionia buoliana*, and *Choristoneura* spp. Pheromone identification was difficult for several reasons: a confused taxonomy, an unclear life cycle, and minute quantities of pheromone present in female glands. The compound that was finally identified (Z,E-9,11 tetradecenyl acetate) is very unstable and so does not reliably attract males in the field. This research effort was suspended because the utility of sex pheromones as a management tool for the fir coneworm appeared highly unlikely. While pheromones have been employed in many monitoring and control methods, they vary widely in their usefulness between species. For instance, excellent early warning and mating disruption techniques have been developed for the Douglas-fir tussock moth, a species where the female does not fly and relies on the sex pheromone to attract males. With the Western spruce budworm, however, the males close range behavior is to "cruise" branches, which may be one of the reasons why there has been less success with disruption of this species. The tiny amount of pheromone released by the fir coneworm and the unstable nature of this compound indicates that this species may rely on other behavioral or chemical cues for finding a mate, making it a poor candidate for pheromone based management. I believe that the Steering Committee and Forest Pest Management need to take a hard look at: 1) the need for this work; and 2) whether the proposed work is a substantial improvement over previous efforts. Finally, the 5 year action plan is highly optimistic.

I hope my comments are helpful.

Best regards,

/s/ CGN

Christine G. Niwa
RESEARCH ENTOMOLOGIST

cc: T.Hofaker, WO

[illegible]

Finally, the 5 year action plan is highly [illegible]

I hope my comments are helpful

Best regards

Raj Chin

Alex Mangini (R-8)

NATIONAL STEERING COMMITTEE
FOR MANAGEMENT OF SEED, CONE AND REGENERATION INSECTS

1993 Report - Alex Mangini, USDA FS, FPM, Region 8, Alexandria, LA

This is the second steering committee meeting I have attended and I have been seed and cone entomologist at the USDA, Forest Service, Forest Pest Management (FPM) Alexandria Field Office for about two and a half years now. The projects that I am involved in at this time are:

1. Simulation of Aerial Insecticide Sprays (FPM Technology Development Project, with Larry Barber, Scott Cameron and Bob Sanderson)

2. Mating Disruption of Coneworms (FPM Technology Development Project, with Gary DeBarr, Jack Nord, Larry Barber and Chris Niwa)

3. Foray/Capture Pilot Tests (FPM Technology Development Project, with Larry Barber)

4. Environmental Impact Statement for Erambert/Black Creek Seed Orchards, Mississippi

5. Southern Seed Orchard Pest Management Subcommittee projects
   -Capture (bifenthrin) Study
   -Guthion (azinphosmethyl) Rate Study
   -Asana (esfenvalerate) Rate/Timing Study

6. Southwide Coneworm Survey

7. Ecosystem Management on Ozark/Ouachita National Forests - team member on the Arthropod and Microbial Communities Study Group

SIMULATION OF AERIAL INSECTICIDE SPRAYS

A. Ground-based Aerial Spray Simulator (G-BASS)

   1. The G-BASS Spray System - A ground-based sprayer (G-BASS) has been designed to simulate deposits typical of aerial sprays in southern pine seed orchards. As a preliminary step in developing a system, a single nozzle was set up in an enclosure built in a shed at the Texas Forest Service (TFS) nursery to determine wind speeds generated at various distances from the spray head. Also, droplet sizes, deposits and swath width were determined on water-sensitive cards using a shutter system built to provide equal exposure times for all cards.

      The first G-BASS model tested in the field consisted of a single nozzle mounted at the end of a short antenna mast on a platform attached to a John Deere tractor and was designed to treat small trees, up to about 6-8 ft. tall. The components of this spray system included a spray tank (plastic beverage bottles), a carbon dioxide bottle with pressure gauge to pressurize the system and regulate flow, a Micronair AU7100 spray nozzle with hydraulically driven fan and atomizer (driven by the tractor hydraulic system), and a needle valve and tachometer to monitor and regulate the speed of the fan blade and droplet size.

      A G-BASS system was then developed to spray seed orchard trees up to 25 ft. tall. This system is the same as the one described above

except that it includes a boom constructed of square steel tubing and bars reaching about 22ft. above the ground and is equipped with three Micronair AU7100 nozzles driven by the hydraulic system on a John Deere tractor.

2. Field Test - Nantucket Pine Tip Moth - A G-BASS spray system for treating small plantation pine trees was used in a spray-timing efficacy test in a loblolly pine plantation near Wells, Texas. A separate hydraulic sprayer also was built and mounted on the platform for applying high volume sprays. This equipment was used to conduct a replicated Nantucket pine tip moth (NPTM) degree-day timing test using esfenvalerate (Asana XL) (ULV), dimethoate (Cygon) (HV), and Bacillus thuringiensis (Foray) (ULV) during May-June 1992 in a five-year old loblolly pine plantation. Results will be compared to those obtained in Georgia where the NPTM spray timing model was developed. Pheromone traps were monitored daily throughout the second NPTM emergence peak (May 1992) in two loblolly pine plantations to determine the time to initiate the degree-day model and to compare the amplitude and length of the emergence peaks in these two plantations. A Campbell Scientific meteorological station was used to document weather conditions during each spray. Significant differences in the mean percent tip moth damage were observed among many of the treatments and very little damage was observed with single spray applications of Asana XL and Cygon at the optimal spray timing.

   Important results:

   -Bt is effective in control of NPTM - first time to be demonstrated.

   -Timing is different for NPTM using Bt - late sprays more effective.

   -ULV esfenvalerate as effective as HV dimethoate.

3. Safety - Jerry Edwards, USDA Forest Service mechanical engineer, observed the setup on-site in Texas in April 1992 and stated that the boom was more than adequate to support three nozzles and approved continued development of the sprayer. However, the boom design was subsequently changed from a telescoping tube type to a strut-reinforced column constructed of steel tubing and reinforcement bars. In May 1993, Jerry Edwards returned to analyze the redesigned G-BASS. His examination determined that the unit is safe to operate.

4. G-BASS Seed Orchard Trials

   a. Technique Development - The G-BASS was tested in a loblolly pine seed orchard belonging to International Paper Company (IPCO). The trees were 20-25 ft. tall. Twelve spray tests were conducted with the G-BASS in the IPCO orchard between August 25 and September 1992 to determine the best way to deliver spray deposits similar to those recorded in the Evans seed orchard aerial spray trials (drop size about 300 microns VMD and 0.87 gal/ac, or two times that recorded for the 5 gal/ac since 10 gal/ac is the rate usually used for aerial applications in pine seed orchards). A Campbell Scientific meteorological station was used to document weather conditions during each spray. Deposits of about 300 microns VMD and 2 gal/ac were recorded on spray cards on cans in test tree canopies when sprayed on all four

sides at a calibrated rate of about 7 gal/ac using the nozzles at 3,000 RPM's and blade angle position 4.

b. Seed Bug Bioassay - A leaf-footed pine seed bug, Leptoglossus corculus, bioassay for Asana XL was done. Three rates of Asana XL (3, 14 and 70% of the registered aerial application rate) were applied to each of three trees with the G-BASS sprayer on September 9, 1992. Branch samples from each of the treated trees and three check trees were collected on the day of application and from the trees treated at the high rate at weekly intervals for 4 weeks after treatment. These samples were sent to Dr. Jack Nord, USDA Forest Service, in Athens, GA where he conducted a bioassay with seed bugs from his laboratory colony. Corrected mean percent mortality ranged from about 5 to 70% among the three treatments on the day of application. Residual effects at the high rate vanished by three weeks after treatment.

c. Drop Size Deposition Test - A test was conducted in the IPCO seed orchard on October 21 to compare deposits between two different drop sizes at the same application rate and similar sprayhead wind speeds of air using the G-BASS sprayer. An average of about 3 gal/ac were deposited on cards in trees sprayed with 300 micron VMD drops (3,000 RPM's, blade setting 4) compared with about 1 gal/ac on cards in trees sprayed with about 150 VMD drops (7000 RPM's, blade setting 2).

B. Aerial Application Data

1. 1991 Erambert Seed Orchard - Spray deposition data from two spray configurations and formulations were collected on a variety of sampling devices at the USDA Forest Service Erambert Seed Orchard in June 1991. These trials were designed to test fluorometric and standard spray card deposition techniques and to document spray deposition typical of aerial sprays in southern pine seed orchards. Weather data was collected on two meteorological stations at the orchard throughout these spray trials.

2. 1992 Evans Seed Orchard - Four aerial sprays with dye and water, two with standard hollow cone pressure nozzles and two with Micronair AU5000 nozzles, each applied at 25 and 40 ft. above the ground, were applied at the Boise Cascade Evans Seed Orchard near DeRidder, LA, in June 1992. Weather data were collected with three weather stations and deposition data were collected from spray cards and from pine needles using fluorometric analysis.

C. FSCBG Aerial Application Model Comparisons - As mentioned above, the data collected at the Evans Seed Orchard trials were used to verify the FSCBG spray model predictions for above, within and under canopy and drift card deposition. Spray drift and deposition data from the Evans applications were compared to deposition predictions from FSCBG. Highest correlation with FSCBG prediction was obtained for lower spraying height and larger droplet size spectra. The analysis was presented by Bob Sanderson at the American Society of Agricultural Engineers meeting held at Spokane, Washington in June of 1993 (Sanderson, R., A. Mangini, S. Cameron and L. Barber. 1993. Aerial spray deposition trials and FSCBG verification. Paper 931059. American Society of Agricultural Engineers.)

D. Fluorometric Analysis

1. Turner Fluorometers - Two Turner fluorometers were purchased by FPM (Asheville and Alexandria Field Offices) for measuring spray deposits. These machines are being used in the current project to monitor spray deposits in pine seed orchards using rhodamine WT dye. One of the machines currently is located at the TFS Pest Control Lab. As a preliminary step in testing a variety of potential artificial targets for monitoring spray deposits in pine seed orchards, a dye stability test on three targets (acetate sheets, stainless steel welding rod, and heavy monofilament line) was conducted in Lufkin. It was discovered that the fluorescence of rhodamine declines rapidly in sunlight by 30% in one hour and 50% in four hours.

2. Spray.BAS - A computer program was developed by Bob Phillips under contractual agreement with Larry Barber. The program is designed to calculate concentrations for tank mixes and spray deposits using the Turner Fluorometer.

3. Evans Seed Orchard Test Spray - Spray deposits were measured for each of the Evans Seed Orchard aerial spray tests using the Turner Fluorometer after each spray application at the orchard site.

E. Card Reading System - A video camera and computer system have been developed by Bob Sanderson for capturing images (spray drops) on cards and computing mean VMD's, drops/cm^2, and volumes. FPM has two of these systems (Alexandria and Asheville Field Offices) and another is located at New Mexico State University (NMSU). The Alexandria system is located at the TFS Pest Control Lab in Lufkin and has been used to measure spray deposition for each of the various steps in developing and field testing the G-BASS sprayers. Spray deposits in the Erambert and Evans seed orchards were analyzed at NMSU.

F. 1993-94 Work - Carryover funds will be used to further test G-BASS to determine effects on deposition of wind and air-assistance, best application techniques and practicality for further use. Tests will include a second efficacy/timing test for NPTM with Foray alone and with Rhodamine dye to determine effects of Bt and dye on efficacy.

MATING DISRUPTION OF CONEWORMS

This FPM Technology Development project was has been underway since 1990 and has received new funding for 1993-94. I and my technicians at the Alexandria Field Office have participated in some of the field work on this project, primarily the work done at the USDA Forest Service Stuart Seed Orchard in 1991 and 1992. I defer detailed discussion to Larry Barber who is the FPM leader of the project.

FORAY/CAPTURE PILOT TESTS

This FPM Technology Development project is now completed. Preparation of a final report and publication are now underway. Results indicate that Bt (Foray) is effective in controlling coneworms. Additionally, the Bt in combination with the synthetic pyrethroids esfenvalerate (Asana) or bifenthrin (Capture) provides effective control for coneworms and seedbugs.

ENVIRONMENTAL IMPACT STATEMENT - ERAMBERT/BLACK CREEK ORCHARDS

The environmental impact statement for pesticide use on these two orchard is now being prepared. Risk analyses for the pesticides in use have been completed by Labatt-Anderson under contract with the USDA Forest Service.

SOUTHERN SEED ORCHARD PEST MANAGEMENT SUBCOMMITTEE

The Southern Seed Orchard Pest Management Subcommittee (SSOPMS) is sponsored by the Southern Forest Tree Improvement Committee. It was formed several years ago to address the critical need for new and safer pesticides to use in southern seed orchards. The subcommittee consists of entomologists from FPM-R8 and research entomologists from the USDA Forest Service Southeastern Forest Experiment Station (SEFES). Additionally, state and industry are represented by the directors of the three southern tree improvement cooperatives. The SSOPMS meets twice yearly to discuss new pesticides and insect control developments. It sets priorities for cooperative efforts in the southern seed orchards. As a result of its efforts, three large-scale studies have been done in the last three years. The Southwide Capture (bifenthrin) Study established the efficacy of this insecticide for control of seed and cone insects and resulted in its registration in most of the southern states. The Guthion (azinphosmethyl) Rate Study determined that the rate of application of this pesticide on seed orchards can be reduced greatly while maintaining efficacy. In 1993, SSOPMS is sponsoring a rate/timing study for Asana (esfenvalerate).

SOUTHWIDE CONEWORM SURVEY

Since 1981, a survey has been conducted using sticky traps baited with synthetic pheromone to monitor populations of the southern pine coneworm, *Dioryctria amatella*, the blister coneworm, *D. clarioralis*, the webbing coneworm, *D. disclusa*, and the loblolly pine coneworm, *D. merkeli*. The survey is a cooperative effort among FPM-R8; the SEFES; and cooperating industry, state and federal pine seed orchards. The Southwide Coneworm Survey provides site-specific and regional information on the distribution, abundance and seasonal activity of the coneworm species. This information can be used to assist in pest management and research work on coneworm biology.

Each year FPM sends out a request for participation to orchards in the South; in the meantime; SEFES loads the rubber septa baits with the pheromone and forwards them to FPM. After the cooperators respond, FPM, in turn, sends baits, data sheets and instructions. Cooperators install and check the traps and send the completed data sheets to the FPM Alexandria Field Office where the survey database is maintained. It is hoped that, in the future, the survey can become part of an integrated pest management program combining the survey, degree-day models and meteorological data collection to provide managers with an automated system for making treatment decisions.

ECOSYSTEM MANAGEMENT - OZARK/OUACHITA NATIONAL FOREST

A large, replicated study is underway on the Ozark/Ouachita National Forest to determine the effects of various silvicultural methods on forest health. My participation is as a member of the Arthropod and Microbial Communities Study Group. The group is conducting surveys of arthropod biodiversity on several of the treatment plots. My responsibility in the group is to identify mites collected in soil and litter samples. Additionally, Dr. James Hanula of the SEFES and I plan to survey seed and cone insects in shortleaf pine and seed-infesting insects in oaks.

SURVEY OF STATE COOPERATORS - SEED AND CONE INSECT MANAGEMENT NEEDS

As a result of the change in emphasis in the agency resulting from the move to an ecosystem-oriented management philosophy, the Seed, Cone and Regeneration Steering Committee must reevaluate its past work and future activities. In anticipation of the discussion of the future work in seed and cone management, Jack Barry asked me to contact several of our state cooperators in the Southern States to get an idea of the needs that the cooperators consider to be important. The results of the survey are summarized in the following paragraphs.

The primary need for research and development in seed, cone and regeneration work is the application of behavioral chemicals (pheromones) in the management of insect pests. This management should involve using behavioral chemicals for both absolute reduction in insect numbers and the appropriate timing of pesticide sprays.

The production of improved seed should be coordinated with the economic demands for the seedlings. Insect and disease resistance should be part of the genetic improvement program. It is necessary to determine susceptibility to insects and diseases. Susceptibility is not the same as lack of resistance.

Azinphosmethyl (Guthion) should remain as a seed and cone insecticide. There are no serious resistance problems with this compound, proper aerial application is safe, and it is economical and not environmentally significant because of the small acreages treated.

There are now no granular insecticides registered for use in seed orchards (with the recent deregistration of carbofuran). There needs to be some effort given to developing new granular pesticides. As an alternative to this, there should be work on developing and registering pesticides that can be injected into trees so that single trees can be protected from pests.

Efficacy and other development tests need to be conducted for more than one season because of the natural fluctuations in insect populations. Preferably, studies should be conducted for several years to avoid artifacts due to the natural fluctuations in populations. Additionally, these studies should not be done in managed orchards which have operational sprays. This again can cause artificial results due to the suppression of insect populations throughout the orchard, not just in the test plots.

Another subject for further technology development is the production of longleaf pine seed and seedlings. This is a regeneration need also. There are difficulties in storing longleaf seedlings before planting. Also needed are studies on pollination and seed production and on growth and yield. The federal agencies should take the lead in these studies.

Much needs to be done looking at the production of wildlife mast by hardwoods. Little is known about the hardwood seed production in terms of insect loss and damage. It remains to be determined what hardwood species are best adapted to specific edaphic conditions (growers do not know what to grow). Present hardwood culture is using misting to keep seedling roots moist. Lifting and storage processes are flexible. However, at present, survival rates for much of the hardwood planting is still unknown. This needs to be determined.

One important aspect of current seed orchard insect control is the cost of insecticide applications. Much application today is done on contract basis and there is an increasing trend in inter-agency/company cooperation in insect

control. This orchard integration is being coordinated by the tree improvement cooperatives. Thus, more than one orchard is contract-sprayed at the same time and these orchards may belong to several companies and/or state agencies.

The bottom line is that technology needed is anything that will cut costs and reduce the amount of insecticide used in seed orchards. The tree improvement cooperatives are very effective in technology transfer and pest control coordination.

The Seed, Cone and Regeneration Steering Committee should attempt to keep these needs in mind when setting priorities. We need to continue to be sensitive to state and industry needs even as we move more toward ecosystem-oriented projects within the agency. The committee should attempt to be focused and balanced in its efforts.

United States Department of Agriculture	Forest Service	Ashe Nursery Erambert Seed Orchard	368 Ashe Nursery Road Brooklyn, MS 39425

Reply to: 2150

Date: January 31, 1992

We are in the process of developing the pest management program for the Erambert and Black Creek Seed Orchards. I have inclosed documentation which outlines my decision on methods of application and insecticides to be used for control of cone and seed destroying insects, bark beetles and insects which damage newly planted orchard grafts.

The 1992 planned program will include five aerial applications of a Foray and Asana insecticide mixture, and one application of Guthion WP. The aerial applications are scheduled for March 24, April 21, May 19, June 16, July 14 and October 20. The applications will be 74 - 124 acres per application. Weather and other factors can cause this schedule to change. If you would like to be informed of schedule changes, let us know. The neighbors near the Erambert Orchard which we have been contacting prior to spraying will continue to be notified.

Bark Beetles will be controlled in the orchard by cutting and removing the trees, except in the cases of rare clones where Dursban will be used to save the tree.

Newly outplanted grafts in the Black Creek Orchard site will be protected with applications of granular Furadan at the time of planting.

If you have any comments or Questions on our pest management program, we would like to here from you. You may contact Jerry Windham at Ashe Nursery or by calling (601) 584-8488.

Jerry W Windham

JERRY W. WINDHAM
Orchard Manager

DECISION NOTICE
AND
FINDING OF NO SIGNIFICANT IMPACT
ASHE ERAMBERT PROJECT
USDA - FOREST SERVICE
NATIONAL FORESTS IN MISSISSIPPI

An environmental assessment that discusses the proposed management direction for the pest management program at the Erambert Seed Orchard is available for public review in the Forest Service office at W. W. Ashe Nursery in Brooklyn, Mississippi. This environmental assessment was approved 12/18/87 prior to the fiscal year 1988 spraying program. The analysis done in this assessment is still valid. The differences between the program for fiscal year 1992 and fiscal 1988 includes a reduction of acreage, sources to be sprayed, schedule, and a change to the application of Foray as the primary pesticide used.

During 1991 we began an Environmental Impact Statement (EIS) planning process. We hosted a public open house at the Erambert Seed Orchard as a part of the scoping process for the EIS. The following concerns were raised at this meeting by those attending:

1. A tin roof is rusting. Could that be related to aerial spraying of pesticides?

2. One has respiratory problems and headaches during spray projects.

3. The Erambert Seed Orchard has provided jobs for local people.

4. Could disease from trees on their property spread to trees in the seed orchard?

Issue number 2 has been addressed in the current EA and Project Safety plan for the 1992 spray project. The switch to Foray as a biological control and changes in application control measures have been taken to address this issue. All of these issues along with 121 concerns raised by Forest Service staff will be addressed in the EIS.

Foray is a biological control for the larvae of moths. It is very target specific to moth larvae (lepidopterous insects) and does not kill other insects, and is many times safer for animals or humans if exposed. Foray, however, does not control seed bugs. In 1991 we applied Foray with Asana Chemical insecticide added at a rate 7 times lower than label rate normally used in seed orchard applications. The Foray/Asana mix provided good protection from cone worms and seed bug damage seemed to also be controlled by this low rate of Asana.

Due to these promising results testing Foray last year, we are planning to make most of our control applications this year using Foray with Asana added at one eighth the normally applied rate. We will be trying applications with several further reduced rates of Asana again to see how little insecticide can be used and still control seed bugs.

Guthion will be used this year for one application to 74 acres to be made in October.

Areas in which breeding work has been done are included in the area to be sprayed aerially. This will reduce worker exposure to chemicals.

Dursban insecticide will be used instead of Lindane if needed for bark beetle control. Dursban has a lower level of toxicity to animals than Lindane.

Hand application of Furadan granular insecticide is planned for protection of newly planted grafted trees to be planted at the Black Creek Orchard site. The Furadan is primarily to protect the trees from tip moth damage, but will also protect the trees from sawflies, aphids and spider mites. This use was not covered in the EA. The use consists of one application of 7 grams of Furadan granules placed by hand in the planting hole at the time the trees are planted. Approximately 1000 trees will be treated.

Based on the analysis described in the Environmental Assessment which is still current, my decision is to adopt alternative A. Use aerial application as the primary method of applying insecticides for pest management at the Erambert Seed Orchard.

The selected alternative will include:

1. Six aerial applications from March 24 through October 22 on 74 to 124 acres per application.
2. Control bark beetle spread by cut and removal of infested trees. Use Ground application of Dursban insecticide only to save rare clones or in the case of epidemic build up of Southern Pine Beetles around the orchard.
3. Control tip moth attack on newly planted grafted trees with the application of Furadan at the time of planting.

Alternative A. was selected because:

1. Provides the least costly method of insect control.
2. Provides the most efficient control of insect populations.
3. Provides the greatest degree of safety by requiring less chemical to be applied per acre, applying over a shorter time span, reducing worker exposure, and reducing the potential for off site drift.

Other alternatives considered were:

Alternative B. Use ground application as the primary method of applying insecticide.

Alternative C. No insect control by chemical means.

I have determined from the analysis and considering the fact that an EIS is currently being developed to cover pest management that this is not a major federal action that would unreasonably affect the quality of the human environment and that an environmental statement need not be completed prior to implementing this year's pest control project.

Implementation will take place immediately after the date of this decision.

This decision is subject to administrative review (appeal) pursuant to 36 CFR 217. Any written notice of appeal of this decision must be fully consistent with 36 CFR 217.9, "Content of Notice of Appeal," including the reasons for appeal and must be filed with: Forest Supervisor, 100 W. Capitol St., Suite 1141, Jackson, Ms. 39269 within 45 days of the date of this decision. Simultaneously, send a copy of the notice of appeal to my office: Orchard Manager, Ashe-Erambert Project, 368 Ashe Nursery road, Brooklyn, Ms. 39425.

For further information, contact Jerry Windham, Orchard Manager at the Brooklyn address or at (601) 584-8488.

Jerry W. Windham
JERRY W. WINDHAM
Orchard Manager

1/31/92
Date

Nancy Rappaport (PSW)

1993 REPORT: SEED, CONE, AND REGENERATION INSECTS STEERING COMMITTEE

Nancy Rappaport, PSW Research Station, Albany, CA

Current Research:

1. Stereochemistry of western cone beetle behavioral chemicals (Rappaport, Seybold, Francke and Page).

2. Impact of cone and seed insects on sugar pine seed production at Badger Hill Clone Bank (Rappaport, Samman, and Stover).

3. Impact of cone and seed insects on sugar pine seed production at Foresthill Seed Orchard (Rappaport, Trummer, and Binder).

4. Impact and control of Port-Orford-Cedar cone and seed insects (Rappaport, Sandquist, and Greenup).

5. Athropod-induced abortion of first-year sugar pine cones (Rappaport, Sniezko, Danielson, Kitzmiller, Samman, and Stover).

6. Mechanisms of megagametophyte induction in Douglas-fir by *Megastigmus spermotrophus* (Rappaport and DuMas).

7. *Megastigmus albifrons* in ponderosa pine: potential for development of larvae in unfertilized seed (Rappaport and Stein).

8. Arboreal sprinklers for single-tree treatment against cone and seed insect attack (Rappaport, Barry, Herzber, Stein, and Catchpole).

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Estimating the Effect of *Megastigmus spermotrophus* (Hymenoptera: Torymidae) on Douglas-Fir Seed Production: The New Paradigm

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ABSTRACT In a pollen-exclusion experiment performed on the cones of five Douglas-fir (*Pseudotsuga menziesii* [Mirbel] Franco) trees, the number of seeds infested by a seed chalcid, *Megastigmus spermotrophus* Wachtl, did not differ significantly between pollinated and unpollinated cones from the same tree. This finding led us to revise the formula used to calculate *M. spermotrophus* impact on Douglas-fir seed production, because the traditional formula, which is based on the assumption that only pollinated seeds are infested by these chalcids, exaggerates their impact. The relationship between the new formula and the traditional formula is nonlinear, varying with both pollination rate and infestation level. To assist other researchers in estimating the error in past chalcid impact studies, we calculated the discrepancies for a range of pollination rates. Past assessments were strongly biased only where pollination rates were below 70% and chalcid attack rates were from 50-85% using the traditional formula. For low pollination rates, the discrepancy can exceed 50%. Evidence is presented to explain how the unfertilized female gametophyte, which is small and is normally resorbed in the absence of pollination, can support the development of chalcid larvae. In this study, there was a strong correlation (-0.93) between cone length and chalcid attack rate.

KEY WORDS:

Insecta, seed orchards, seed chalcid, impact assessment

REFORESTATION OF DOUGLAS-FIR (*Pseudotsuga menziesii* [Mirbel] Franco) following harvests, wildfires, or pest epidemics depends on a reliable supply of high-quality seed. As a consequence, industry and government agencies have established conifer seed orchards for the production of such genetically improved seed, which has been valued at up to $2,000/kg.

Megastigmus spermotrophus Wachtl, a seed chalcid, is an important pest of Douglas-fir seed production both in the natural range of Douglas-fir in North America and in European countries where introduced Douglas-fir has become an important component of the timber economy. The seed chalcid has been reported to destroy 20% or more of Douglas-fir seed in the Pacific northwestern U.S. (Schowalter et al. 1985), and reported attack rates in European seed orchards often exceed 90% (Roques 1981). Seed chalcid impact assessments have previously been based on the assumption that chalcid larvae require pollinated ovules in order to mature successfully, because unpollinated ovules have only a small amount of tissue which is resorbed by the plant if pollination is unsuccessful (Allen & Owen 1972).

The formula traditionally used to calculate the chalcid attack rate (Lessmann 1974, Roques 1983), denoted by T, is based on the assumption that all chalcid-infested seeds would, in the absence of other cone and seed pests, have produced sound seeds:

$$T = \frac{Infested}{Infested + Sound} \quad .$$

where

$Infested$ = number of chalcid-infested seeds/cone

$Sound$ = number of remaining sound seeds/cone after chalcid attack.

If chalcids do not require pollinated seeds, then previous assessments of seed chalcid impact have clearly been inflated by an undetermined amount.

Results from earlier studies in northern California (N. R., unpublished data) and central France (A. R. & N. R., unpublished data) supported the hypothesis that chalcids do not require pollinated seeds to produce viable progeny, but chalcid populations were low in both cases, with infestation levels of 1-5% in both pollen-exposed and pollen-excluded cones. We concluded that a third study, with higher chalcid populations, was necessary to provide convincing evidence that chalcid larvae in pollen-excluded cones did not result from accidental pollen contamination in those cones.

A second objective was to develop an accurate formula for assessing impact and to determine the potential discrepancies between this new formula and the traditional impact formula. The reason for calculating these potential discrepancies was to assess the magnitude of previous overestimates of chalcid impact; if these overestimates were small, those studies (Lessmann 1974, Hedlin et al. 1980, Roques 1981) retain some utility in ranking importance of seed chalcids compared to other pests of Douglas-fir seed production.

Finally, we wished to assess the correlation previously reported (Lessmann 1974, Rappaport & Roques 1991) between cone size and chalcid attack rate, using greater numbers of cones per tree and sampling them closer to the time of oviposition, which is when hosts are selected. Cone size is known to have a genetic component, so a strong correlation between cone size and chalcid attack might provide the basis for a genetic resistance program in seed orchard design.

Materials and Methods

The study was conducted at the USDA Forest Service Monmouth Breeding Orchard near Monmouth, Oregon. Four to 19 ramets each of 20 clones were grafted in this 2-ha orchard in 1973 and 1974; ramet height was maintained at a constant 5-6 m by topping. We selected five conebearing trees at random, each with at least 40 conebud clusters that had not yet flowered (budscales were still tightly appressed), then replicated each of the following treatments 10 times on each tree (one cluster of seed cones represents one replicate): 1) exclude pollen, then expose cones to chalcids; 2) exclude both pollen and chalcids; 3) expose cones to pollen, then expose them to chalcids; 4) expose cones to pollen, then exclude chalcids.

Pollen exclusion was accomplished by enclosing cone clusters (2 to 8 cones) in pollination bags before budburst; female cones are receptive to pollination as soon as bracts emerge from the budscales (Ho 1980, Owens et al. 1981), so it was crucial to accomplish the bagging before that point. Male cone buds occur on terminal branches near female cones; to avoid self-pollination within the pollen exclosure bags, we identified male cones using the criteria of Allen and Owens (1972) and removed all of them by hand. To reduce the possibility of contamination by errant pollen grains, we rinsed female buds with water before bagging them. This served the dual purpose of washing off any pollen grains that might have been present and of forcing their premature germination.

Chalcid exclusion was accomplished by enclosing cones in pollination bags during the seed chalcid oviposition period, from mid-April to mid-July. In mid-July, one cone was randomly chosen from each treatment and was measured and dissected scale-by-scale to assess chalcid presence before the formation of *Contarinia oregonensis* Foote (Diptera: Cecidomyiidae) galls, which might have interfered with our assessments. Voucher

specimens were deposited at the USDA Forest Service, Pacific Southwest Research Station, Albany, California.

Results and Discussion

Development of Chalcids in Unpollinated Seeds. Pollen exclusion and chalcid exclusion treatments were successful: no sound seeds occurred in the pollen exclusion treatments, and no chalcids were found in the chalcid exclusion treatments (Tables 1 and 2). Numbers of chalcids per cone for pollinated and unpollinated cones from the same tree were not significantly different (Wilcoxon signed rank test, α =0.05) (Snedecor and Cochran 1967) (Table 1). These results indicate that chalcids apparently do not distinguish between pollinated and unpollinated seeds, a finding in agreement with recent results reported by Niwa & Overhulser (1992).

At the time of fertilization, the female gametophyte does not appear to contain enough nutrient to support the development of a chalcid larva; if fertilization does not occur, the clear, watery female gametophyte is resorbed (Owens et al. 1991). If pollination and successful fertilization do ensue, however, the female gametophyte, under hormonal stimulation from the developing embryo, develops within 3 mo. to a large, opaque, solid mass containing sufficient nutrient to sustain the plant embryo through germination.

Owens et al. (1981) use the criterion of normal development of the nucellus as an index of successful embryogenesis; the nucellus, a gray membrane that surrounds the female gametophyte, is clearly visible through the immature seed coat from ca. July 1 to August 1. All chalcid-infested seeds from pollen-excluded cones in our study showed normal nucellar development; this result was unexpected because embryogenesis is exceedingly rare in the absence of pollination (Allen 1942, Orr-Ewing 1957). This

phenomenon occurred only in pollen-excluded seeds that had been subjected to chalcid attack; all pollen-excluded megagametophytes that were protected from chalcid attack aborted and were completely resorbed. We found no embryos in the chalcid-infested, pollen-excluded seeds (chalcid larvae had already consumed the central seed tissues), but many of these seeds still contained normal-looking female gametophyte tissue. Either oviposition or some factor associated with the larvae, then, must stimulate continued development of the female gametophyte in unpollinated seeds. This finding explains how unfertilized seeds, which normally cease to develop, can support the development of chalcid larvae. The mechanism by which chalcid oviposition and/or larval development induces and sustains megagametophyte development is the subject of current studies.

Revised Formula for Estimating Impact of Chalcids. In view of these results, we developed a new formula for calculation of chalcid attack rate, denoted by N, that accounts for the fact that some chalcid-infested seeds might not have produced sound seeds in the absence of chalcids:

$$N = \frac{Pollinated - Sound}{Pollinated}$$

where

$Pollinated$ = number of pollinated seeds per cone.

$Sound$ = number of remaining sound seeds per cone after chalcid attack.

The number of pollinated seeds per cone is estimated by counting the number of sound seeds in chalcid-excluded cones of the experiment. This method requires the exclusion of chalcids from a sample of cones; the minimum number of replicates required depends on chalcid population variability, and must be calculated for each site and for the desired statistical power. It also requires that other pest species in the complex (i.e.,

C. oregonensis, *Barbara colfaxiana* [Kearfott] [Lepidoptera: Olethreutidae], *Dioryctria abietivorella* Grote [Lepidoptera: Pyralidae], and *Leptoglossus occidentalis* Heidemann [Hemiptera: Coreidae]) be excluded from that subset of cones in order to derive an accurate assessment of the production of potential sound seed. Because chalcid exclusion from a subset of cones is necessary for an assessment of impact, precise retroactive assessments are not possible. Thus, many previous chalcid impact studies clearly have inflated impact values. To the extent that chalcids mask the occurrence of unfertilized seeds, the impact of other cone and seed insects has also been inflated.

Relationship Between New and Traditional Impact Formulas. It is obvious that the impact of chalcids, as estimated by the traditional formula, will be more or less biased depending on the rate of pollination of seeds and the rate of infestation. The formula below shows the mathematical relationship, which is nonlinear, between the two chalcid attack rates T and N. It is assumed that pollinated seeds are just as likely to be attacked as unpollinated seeds, an assumption that we are currently testing:

$$T = \frac{N}{P + N(1 - P)} \tag{1}$$

where

P = pollination rate/cone

N = chalcid attack rate using the new impact formula

T = chalcid attack rate using the traditional impact formula.

If the pollination rate is 100%, then $T = N$, and the two formulas give identical results. If $P<1$, as is normally the case, then $T>N$. In other words, for all real-world ranges of pollination, the traditional formula produces an inflated estimate of chalcid damage. The degree of discrepancy between the traditional and new attack rate formulas

can be assessed by the formula for their difference as a function of the traditional rate and the pollination rate, given in equation (3) below:

we obtain N from equation (1) above:

$$N = \frac{TP}{1 - T(1-P)} \tag{2}$$

$$T - N = T - \frac{TP}{1 - T(1-P)} = \frac{T - T^2(1-P) - TP}{1 - T(1-P)}$$

so

$$T - N = \frac{(1-P)(T-T^2)}{1 - T(1-P)} \tag{3}$$

Figure 1 indicates that past impact assessments were strongly biased only where pollination rates were below 70% and chalcid infestations were from 50-85% using the traditional formula. For a pollination rate of 10% and chalcid infestation rate (T) of 75%, however, the discrepancy exceeds 50%. According to previous impact studies, chalcid infestation rates are characteristically much higher in Europe than in North America; North American infestation rates are usually below 20% (Hedlin et al. 1980; Schowalter et al. 1985), while rates of 30-90% are common in Europe (Roques 1983). Pollination rates are impossible to sample after the fact, but a 2-yr. study by Ho (1980) in Oregon seed orchards reports that an average of 70% of Douglas-fir ovules contained one or more germinated pollen grains, a rate of pollination that would be consonant with an error rate (T-N) of 9% for a value of T around 50%. Studies conducted in British Columbia report average rates of seed efficiency from 39-85% (seed efficiency is the percentage of normal, filled seeds out of the total of potential seeds per cone, i. e. $SE = 100 \text{ x } P$, where $SE = seed\ efficiency$) (McAuley 1990, Owens et al. 1991). Seed efficiency has been

shown to vary with reproductive phenology in Douglas-fir (El-Kassaby et al. 1984): in 1981, trees flowering early and late had seed efficiencies of 33% and 26%, respectively, while those with intermediate flowering phenologies had seed efficiencies of 50%. In 1982, the seed efficiencies for the same trees were 62% (early), 57% (late) and 85% (intermediate). When assessing chalcid impact, then, seed efficiency must be sampled by excluding all seed and cone insect species from a subset of cones on each tree.

Empirical Comparison of Old and New Formulas. The data from this study were used to estimate the two chalcid attack rates (T and N) and their difference ($T - N$) per tree. In addition, with the estimates of T and N an estimated pollination rate can be obtained by equation (4) below, which is derived as follows:

from equation (1) above,

$$T = \frac{N}{P + N(1-P)}$$

so

$$N = TP + TN - TNP$$

and therefore

$$N - TN = P(T - TN)$$

so

$$P = \frac{N - TN}{T - TN} = \frac{N(1-T)}{T(1-N)}$$

and if $\hat{N}$ is an estimator of N and $\hat{T}$ is an estimator of T, then one can estimate $\hat{P}$ (estimated rate of pollination) as:

$$\hat{P} = \frac{\hat{N}(1-\hat{T})}{\hat{T}(1-\hat{N})} \tag{4}$$

Table 3 shows the two estimated chalcid attack rates and the estimated differences calculated from averaging the total number of seeds (sound or chalcid-infested) by the

number of cone-clusters (10 clusters and 1 cone per cluster). If the same estimation is made per cluster, then the standard error of the estimates can be calculated. The differences ($T - N$) for two of the trees was negative because the new method of determining chalcid impact is a stochastic process; negative differences will be less likely using larger sample sizes.

Correlations Between Cone Size and Attack Rate. Previous studies (Lessmann 1974, Rappaport & Roques 1991) have shown a correlation between cone size and rate of attack by the seed chalcid, smaller cones often being more heavily attacked than larger cones. The refined impact formula described above was used to test the correlation between cone size and attack rate at Monmouth in 1991. Our results show a closer correlation than previously seen (Lessmann 1974, Rappaport & Roques 1991), with a correlation coefficient of r=-0.93 between cone length and chalcid attack rate using the new formula (Figure 2). A possible explanation for this high correlation is that cones were sampled and measured in mid-July, just a few weeks after chalcid oviposition. Cones sampled early in the season have not yet been influenced by other factors, such as attack by other cone and seed insects or differential growth resulting from nutritional differences, that might affect ultimate cone size.

Our results show the importance of a full understanding of insect-host interactions in assessing pest impact. The mathematical relationships presented provide a means of estimating the error in past chalcid impact calculations if the researcher can reconstruct the pollination rate of those past studies, but future impact studies must be designed to account for the new information about chalcid development in unpollinated seeds. Our results demonstrate that, for pollination rates above 70%, the traditional formula for

calculating chalcid impact is, at worst, only about 10% higher than the actual value. For low pollination rates and rates of chalcid infestation that are intermediate to high, the discrepancies are substantial.

Acknowledgment. We thank Donald L. Copes (USDA Forest Service, Pacific Northwest Research Station, Corvallis, Oregon) for his helpful advice and for permission to conduct the study at Monmouth Breeding Orchard. Thomas W. Koerber (Entomological Services Company, Berkeley, California) first suggested to us the possibility that seed chalcids could produce viable progeny in unpollinated seeds; Constance Millar (USDA Forest Service, Pacific Southwest Research Station, Albany, California) provided helpful information about Douglas-fir reproductive biology; David L. Overhulser shared results of a preliminary study with us; Jerry Berdeen (USDA Forest Service, Dorena Tree Improvement Center, Cottage Grove, Oregon) provided invaluable technical assistance.

References Cited

Allen, G. S. 1942. Parthenocarpy, parthenogenesis, and self-sterility of Douglas-fir. J. For. 40: 642-644.

Allen, G. S. & J. N. Owens. 1972. The life history of Douglas-fir. Environment Canada, Forestry Service, Ottawa. 139 pp.

El-Kassaby, Y. A., A. M. K. Fashler & O. Sziklai. 1984. Reproductive phenology and its impact on genetically improved seed production in a Douglas-fir seed orchard. Silvae Genet. 33: 120-125.

Hedlin, A. F., H. O. Yates III, D. Cibrian-Tovar, B. H. Ebel, T. W. Koerber & E. P. Merkel. 1980. Cone and seed insects of North American conifers. Canadian Forestry Service, United States Dept. Agric. Forest Service, and Secretaria de Agricultura y Recursos Hidraulicos, Mexico (Co-op publ., unnumbered); 122 pp.

Ho, R. H. 1980. Pollination mechanism and seed production potential in Douglas-fir. For. Sci. 26: 522-528.

Lehman, E. L. 1975. Nonparametrics: Statistical Methods Based on Ranks. Holden-Day, Inc., San Francisco, 457 pp.

Lessmann, D. 1974. Ein beitrag zur verbreitung und lebenweise von *Megastigmus spermotrophus* Wachtl und *M. bipunctatus* Swederus (Hymenoptera: Chalcididoidea). Z. Angew. Entomol. 75: 1-42.

McAuley, L. 1990. Douglas-fir cone analysis results. British Columbia Ministry of Forests, Silviculture Branch, Internal Report 8653K.

Niwa, C. G. & D. L. Overhulser. 1992. Oviposition and development of *Megastigmus spermotrophus* in unfertilized Douglas-fir seed. J. Econ. Entomol. 85: 2323-2328.

Orr-Ewing, A. L. 1957. Possible occurrence of viable unfertilized seeds in Douglas-fir. For. Sci. 3: 243-248.

Owens, J. N., A. M. Colangeli & S. J. Morris. 1991. Factors affecting seed set in Douglas-fir (*Pseudotsuga menziesii*). Can. J. Bot. 69: 229-238.

Owens, J. N., S. J. Simpson & M. Molder. 1981. The pollination mechanism and the optimal time of pollination in Douglas-fir (*Pseudotsuga menziesii*). Can. J. For. Res.: 36-50.

Rappaport, N. G. & A. Roques. 1991. Resource use and clonal variation in attack rate by the Douglas-fir seed chalcid, *Megastigmus spermotrophus* Wachtl (Hymenoptera: Torymidae) in France. Can. Entomol. 123: 1219-1228.

Roques, A. 1981. Biologie et répartition de *Megastigmus spermotrophus* Wachtl. (Hymenoptera: Chalcidoidea Torymidae) et des autres insectes liés aux cônes dans les peuplements forestiers et vergers à graines français de sapin de Douglas *Pseudotsuga menziesii* [Mirb.] Franco. Acta Oecol. Oec. Appl. 2: 161-180.

Roques, A. 1983. Les insectes ravageurs des cônes et graines des conifères en France. Institut National de la Recherche Agronomique, 149 rue de Grenelle 75341 Paris; 134 pp.

Schowalter, T. D., M. I. Haverty & T. W. Koerber. 1985. Cone and seed insects in Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, seed orchards in the western United States: Distribution and relative impact. Can. Entomol. 117: 1223-1230.

Snedecor, G.W. & W.G. Cochran. 1967. Statistical Methods. The Iowa State University Press, Ames, Iowa. 593 pp.

Received for publication ________________; accepted ________________.

Table 1. Mean number (SD) of *Megastigmus spermotrophus*-infested seeds per cone

	Chalcid-exposed cones		Chalcid-excluded cones	
Tree No.	Without pollen	With pollen	Without pollen	With pollen
1	20.9(4.2)	22.9(7.5)	0(0)	0(0)
2	15.0(4.3)	8.4(3.9)	0(0)	0(0)
3	14.8(6.7)	12.1(6.2)	0(0)	0(0)
4	4.9(3.1)	3.3(2.9)	0(0)	0(0)
5	6.3(3.8)	5.0(2.5)	0(0)	0(0)
Average	12.4(7.6)	10.3(8.6)	0(0)	0(0)

Table 2. Mean number (SD) of sound, uninfested seeds per cone

No.	Chalcid-exposed cones		Chalcid-excluded cones	
Tree No.	Without pollen	With pollen	Without pollen	With pollen
1	0(0)	6.1(4.4)	0(0)	21.4(5.9)
2	0(0)	2.4(3.3)	0(0)	9.4(6.7)
3	0(0)	1.1(1.4)	0(0)	14.5(3.8)
4	0(0)	14.1(7.9)	0(0)	20.8(9.1)
5	0(0)	24.2(13)	0(0)	33.5(10.6)
Average	0(0)	9.6(11)	0(0)	19.9(11.2)

Table 3. Estimated new and old chalcid infestation rates, their differences, and the pollination rate in percentage

Tree	1	2	3	4	5
New formula:	72	75	92	32	28
Old formula:	79	78	92	19	17
Difference:	7	3	0	-13	-11
Pollination Rate	67	84	100	-	-

Fig. 1. Discrepancies between the new (N) and traditional (T) formulas that measure impact of *M. spermotrophus*, for five different pollination rates and all possible values of T.

Fig. 2. Relationship between mean cone length (cm) and mean numbers of seeds destroyed per cone by *M. spermotrophus* for five trees, Monmouth Breeding Orchard, 1991.

Fig. 1

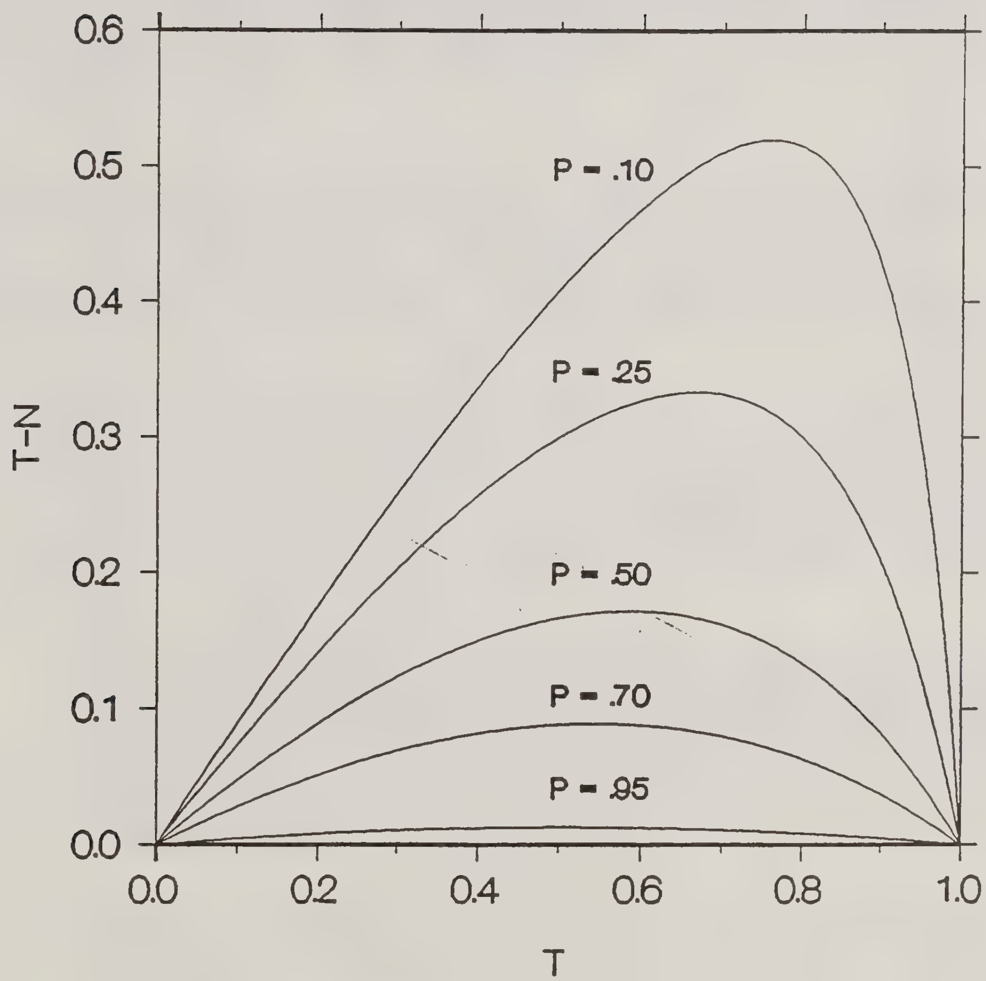
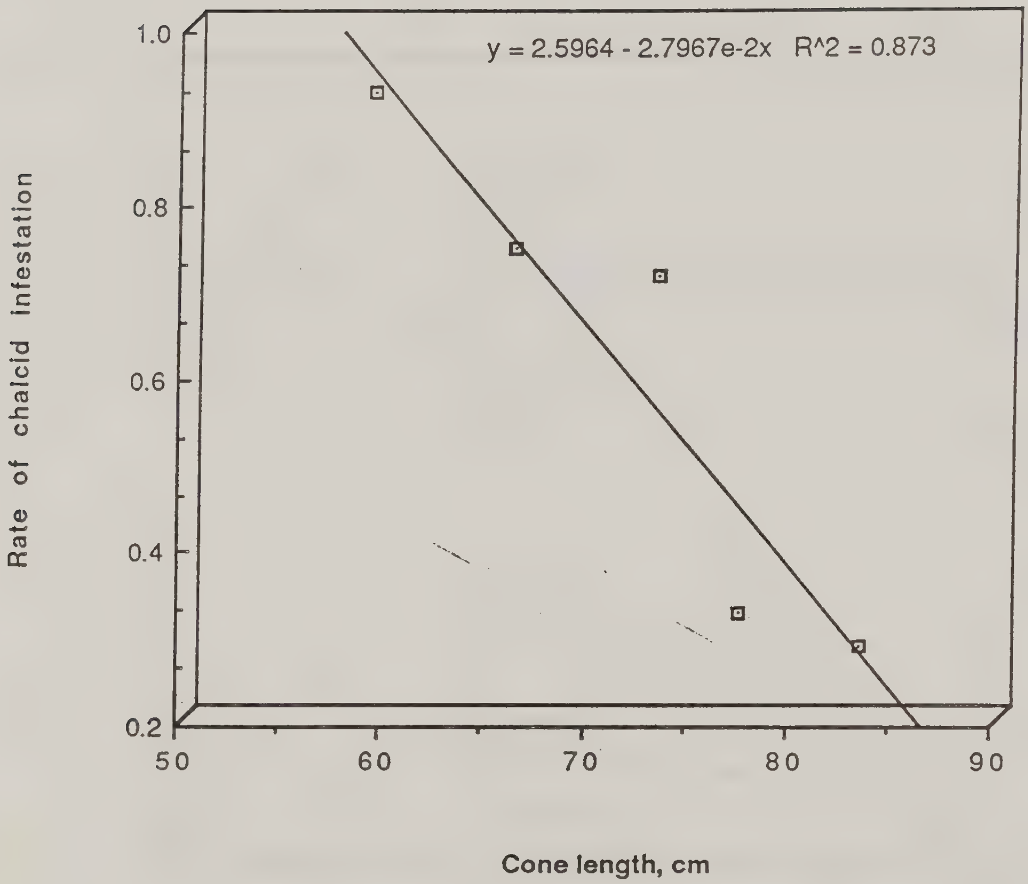


Fig. 2


y = 2.5964 - 2.7967e-2x R^2 = 0.873
Rate of chalcid infestation
1.0
0.8
0.6
0.4
0.2
50
60
70
80
90
Cone length, cm

June 1993
Nancy Rappaport

DRAFT

TACTICAL ACTION PLAN FOR SEED ORCHARD PEST MANAGEMENT

This Tactical Action Plan takes into account the shift in direction mandated by Ecosystem Management (EM). The implications of EM for seed orchard managers, Genetic Resource Programs, FPM specialists, and research include reduced use of pesticides; increased use of pheromones, biological control, and other biorational methods; a shift in species used for reforestation from high-yielding species to species of ecological importance; and an increase in unevenaged management systems resulting in potential new cone and seed insect pest problems.

The format of this Plan is functional, allowing adaptations for changing host and pest problems and modifications to fit changing management needs. The outline of the plan follows fundamental pest management theory, which is based in an understanding of basic pest biology and accurate taxonomic designations; cultural methods are considered the basis of sound pest management, followed by biorational methods when necessary, and pesticides as a last resort.

A. BASIC BIOLOGICAL AND TAXONOMIC INFORMATION. With the shift in emphasis to species of ecological importance that results from EM, new host species are emerging as important components of our Genetic Resources Programs. As a consequence, new and poorly-studied pest problems are becoming increasingly crucial. In addition, there still exists considerable taxonomic confusion in many important genera of seed and cone insects. Basic information must be developed for these groups of insects.

1. Use genetic techniques and behavioral chemicals to clearly establish species separation and host relationships in important North American Dioryctria spp., including D. abietivorella, D. resinosella, D. pseudotsugae. Characterize pheromones and use electrophoresis or mitochondrial DNA techniques to separate species clearly and relate to lifecycle parameters.

2. Use genetic techniques and behavioral chemicals to clearly establish species separations and host relationships in Conophthorus spp., including C. ponderosae from all of its hosts. Pheromones for C. coniperda and C. resinosae have been at least partially characterized; those of C. ponderosae are under study. Genetic methods, including electrophoresis and karyotypy, should be used to resolve question of sibling species in western cone beetles.

3. Behavioral chemicals of Eucosma spp. including E. tocullionana, E. monitorana, and E. sp. near ponderosa must be characterized and species boundaries clarified.

B. IMPACT. Impact of cone and seed insects in the southeastern U.S. has been quite well defined, but in other regions the impact of individual species needs more study. In addition, Genetic Resource Programs are dealing with new host species and a greater variety of host species, and the impact of

cone and seed pest on seed production is virtually unstudied for many of those species.

1. Define the cone and seed insect complex on sugar pine and its impact on seed production.

2. Define the cone and seed insect complex on ponderosa pine and its impact on seed production.

3. Define the cone and seed insect complex on Port-Orford-Cedar and its impact on seed production.

4. Define the seed insect complex on red oak and its impact on seed production.

C. MONITORING. Monitoring methods are still needed for many cone and seed insects nationwide. In many case important behavioral chemicals or other cues have not yet been identified.

1. Develop monitoring systems for Leptoglossus corculus and L. occidentalis.

2. Develop monitoring systems for Conophthorus spp., including C. ponderosae from all of its hosts; a system for C. coniperda and C. resinosae is being developed.

3. Resolve problems with pheromone attraction in Dioryctria spp., and develop effective traps for coneworm monitoring.

4. Develop pheromone-based monitoring systems for Eucosma spp., including E. tocullionana, E. monitorana, and E. sp. near ponderosa.

D. CONTROL. Ecosystem management requires the development, wherever possible, of non-insecticidal control measures for seed and cone insects. Pest management theory posits cultural methods as the cornerstone of pest management, with biorational techniques used as a second line of defense. Insecticidal control is a last resort.

1. Cultural methods.

   a. Resistance may be useful in some cases (e.g. a basis for resistance has been identified for Megastigmus spermotrophus), but may be in conflict with other Genetic Resource Program needs (e.g. disease resistance or increased yield).

   b. Sanitation.

      1. Harvesting of all cones on an annual basis may be cost-effective if the orchard is isolated from other sources of immigrating insects.

      2. Understory burning ("dragonwagon" methods) should be studied in all cases where 1) important cone and seed insects

overwinter in the litter; 2) there are no other nearby sources of reinfestation.

2. Classical biological control.

    a. Parasites of Lepidoptera.

    b. Predators in litter for insects that overwinter in litter.

    c. Fungal and nematode pathogens, especially of Coleoptera.

3. Other biorational methods.

    a. Behavioral chemicals (identification, delivery systems for both monitoring and control).

        1. Pheromones.

            i. Dioryctria spp.

            ii. Conophthorus spp.

            iii. Eucosma spp.

            iv. Cydia spp.

        2. Kairomones (all species).

    b. Sterile male release (flies).

    c. Other genetic methods.

    d. Genetic engineering (B.t. in host genome).

4. Insecticide application (including formulations, rates, application methods, and timing of application.

    a. Chlorpyrifos (encapsulated)

    b. B.t.

    c. Acephate

    d. Malathion

    e. Insect growth regulators

E. IPM SIMULATION/DECISION MODELS.

Roger Sandquist (R-6)

MESSAGE SCAN FOR JACK BARRY

To   m.weiss:w01c
CC   j.space:w01c
CC   m.ollieu
CC   i.ragenovich
CC   j.barry:r05h

From: Roger E. Sandquist:R6/PNW   Host: R06C
Postmark: Jul 08,93 2:04 PM   Delivered: Jul 08,93 2:04 PM

Subject: comments on 1995 Farm Bill

Comments:
Here are some thoughts I have on the subject after discussing this last week at the steering committee meeting.

-------========X========-------

Subject: FPM Role/1995 Farm Bill

To: Mel Weiss
Assistant Director, FPM

This note is a result of the meeting National Steering Committee - Seed, Cone, and Regeneration Insects held June 29 - July 1 in Placerville, CA. We discussed that you are gathering input for the 1995 farm bill. In addition to what Jack may forward to you regarding the committee's recommendation, I submit the following as my personal perspective.

Reauthorization of the Farm Bill presents an auspicious opportunity to expand our authority to participate fully in ecosystem management. Our staffs have the capability to operate as technical specialists in entomology, plant pathology, mycology, etc. beyond strictly pest management. Forest Pest Management can evolve from an organization focusing almost exclusively on the protection of natural resources from insects and diseases to one that also includes responsible advocacy for invertebrates and microorganisms as organisms critical to sustaining ecosystems. Greater emphasis must be placed on strategies which conserve invertebrates and other organisms which are critical to functioning ecosystems as the Forest Service implements the management philosophy of ecosystem management.

I suggest that new Farm Bill language facilitate integration of the following roles, relating to invertebrates and microorganisms, into the fabric of Forest Service (as well as the other Federal agencies we serve) planning, monitoring and decision-making:

Inventory. Many of the temperate forest's biological riches are unknown; so, many of its species have not been described. If we wish to identify a representative sample of species diversity, or to identify those species responsible for important functions of the ecosystem, we must conduct some level of species diversity inventory. This inventory is crucial if we are to monitor the effects (beneficial and negative) of our land management actions.

Ecosystem monitoring. Invertebrates are "indicators" of more than overall biotic diversity. They respond with great sensitivity to variations in ecosystem condition serving as indicators of ecosystem health. Certain invertebrate groups such as pollinators (including bees and flies) and benthic macroinvertebrates (large aquatic insects such as stoneflies and mayflies) can serve as bioindicators of processes central to ecosystem function.

Biological control. One of the threats to biological diversity is the insidious invasion of otherwise healthy ecosystems by aggressive alien species. The displacement of native species can lead to a rapid and long-term disruption of ecological communities. Besides aggressive regulatory programs to prevent their introduction, invertebrates are essential in the control of exotic species, especially weedy plants that threaten the integrity and function of natural communities. Biocontrol successes give cause for hope that some of the most destructive invasive species will be checked. Predatory or parasitic arthropods serve as regulators of the populations of many species considered pests when their populations grow beyond certain thresholds.

Pest Management. Prevention or suppression of "pest" populations of insects or diseases are an integral part of forest management. It is a proper function to assure the continued flow of goods and services to the public. The benefits

as well as the undesirable consequences of various land management tactics must be determined and their effects considered by decision-makers.

Research and Development, Technology Transfer, Training and Education. Despite dramatic advances in our knowledge during the last several decades, we still are woefully uninformed of how the forest ecosystem functions and know even less of the potential effects of our activities on these systems. Invertebrate legacies are in danger of being destroyed before we have a vague understanding of the roles they play. Scientists, policy makers, and land managers must agree upon the high priority research needed to allow responsible land stewardship and they must obtain the resources to gain the information. Mechanisms must be in place to transfer or extend the information in a format which is useful for implementation by land managers. The importance of protecting or restoring the integrity of biotic diversity and ecological processes must continually be emphasized to the public.

The above concepts would make FPMs role very parallel to the role which FIDR changed to a short while ago. FPM specialists would also have roles more in line with other specialists in the Forest Service, focusing less on pest management, but more on all aspects of ecosystem management.

I would appreciate your comments.

Roger E. Sandquist, Entomologist
Forest Pest Management

John Taylor (R-8)

Updated version
from John Taylor
march 1, 1993

Proposed 5-Year Plan for Seed Orchard Pest Management
Southern Region

Southern pine seed orchards are the source of genetically superior seed used for regeneration of pine forests in the South. Approximately 10,000 acres of seed orchards are currently in production and depend primarily on FPM for technical assistance in insect and disease management. The Forest Service, Region 8, has 1385 acres currently in production. These 1385 acres are used to produce seed that is planted into Forest Service and state nurseries, yielding 57 million improved seedlings needed by the region to meet annual reforestation needs. These seedlings have an average cost of $43.00/1,000, or $2,451,000.00 for all 57 million seedlings. Region 8, over the last 5 years, has produced between 10,000 and 30,000 pounds of improved pine seed each year to meet our reforestation needs. Production varies by tree species and by annual insect, disease and weather patterns, but always requires careful management of insect pests if a significant seed crop is to be produced. The region is presently establishing sencond-generation orchards; which will ultimatly result in five additional orchards. In addition, two hardwood seed orchards are being brought under more intensive management for increased production.

Seed production from these orchards is limited by insect damage to both seeds and cones. Failure to adequately control insect damage will result in significant, if not complete, crop loss. Protection of the seed crop is primarily the responsibility of FPM seed orchard entomologists, who, working in conjunction with FS research personnel, have traditionally developed, evaluated and implemented pest control strategies.

The ability of FS research to provide the continuous research support needed to keep abreast of pest protection needs of seed orchard managers has been greatly reduced recently due to decreased personnel and funding levels. The result of this decrease in production of new or improvement of existing control methods has resulted in a serious decline in FPM's ability to successfully control seed orchard insect pests. This plan is designed to provide FPM with the financial and personnel support necessary to resurrect and maintain the role of FPM as the leader in developing and implementing seed orchard pest management technology.

ADDITIONAL PESTICIDE REGISTRATIONS ARE NEEDED TO REPLACE THOSE RECENTLY LOST. THIS IS A CRITICAL PROBLEM IN SEED ORCHARDS. MANAGERS MUST CONTROL INSECTS OR SUFFER CATASTROPHIC LOSSES OF SEED; YET, BECAUSE SEED AND CONE INSECT CONTROL IS A MINOR USE, REGISTRATIONS FOR USE IN SEED ORCHARDS HAVE BEEN LOST FOR MANY PESTICIDES. THESE REGISTRATIONS MUST BE REPLACED TROUGH EXHAUSTIVE FIELD TESTING. THERE IS ALSO AN URGENT NEED TO IMPROVE THE APPLICATION EFFICIENCY FOR THOSE INSECTICIDES ALREADY IN USE.

The primary goal of the plan, from an operational standpoint, is to develop a viable IPM based strategy for managing seed orchard insect pests. This goal has several critical objectives that must be reached if the plan is to be successful. The following is a discussion of the most important problem areas.

Inventory Monitoring

The development of a viable IPM approach to seed orchard pest management depends not only on the use of efficacious, environmentally safe pesticides, but also on the development of systems that can predict potential insect damage, identify the species likely to cause damage, and suggest appropriate control strategies.

One of our major efforts in this area has been the development of an inventory monitoring system which carefully tracks development of the seed crop by tree species by orchard from flowering to harvest, providing data on sources and

frequency of seed damage. Obviously, such a system is only as good as the data fed into it, and insect biology plays a critical role in defining the effectiveness of the system, thus reaffirming the necessity for sound life history data for all major seed orchard insect pests.

Application Techniques

Techniques for applying pesticides to seed orchards are an area that we feel needs clarification. Forest Pest Management has, until recently, been the unquestioned leader in developing more effective application techniques. The FS, and FPM in particular, was instrumental in developing application techniques for all pesticides applied to seed orchards beginning with the use of **Guthion** in 1974. Evaluation of the Powr Til seeder for incorporation of **Furadan granules** was the next major step, (1977) followed by a comprehensive project in 1980 that evaluated the potential for aerial application in seed orchards.

The study showed very clearly that both fixed wing and rotary wing aerial application were viable approaches to applying pesticides in seed orchards, and resulted in pesticide label changes which included aerial application instructions. We have not been able to continue this work answering questions regarding the effectiveness of one pass vs two pass, suitable droplet spectra for optimum coverage, and evaluating the possibility of using lower application rates. We have data from small trials which indicate that lower rates, applied more frequently, may provide better crop protection than current systems, but until funding is available, pilot projects using these methods cannot be implemented.

The potential utility of ultra-low-volume (ULV) applications also needs to be evaluated. ULV is commonly used in many insecticide applications, and may prove beneficial in seed orchards; however, the questions of drift potential, Appropriate VMD, and biological effectiveness must be answered before the system can be implemented. The use of ULV could result in significant increases in control and reduced application costs as has been the case in row crops and vector control programs which made use of ULV technology.

As part of the overall aerial application strategy, we need to evaluate the use of different methods of spray characterization, e.g., the use of different indicator papers, the best methods for predicting and monitoring drift

potential and the possible role of adjuvants, especially the use of spreader stickers, drift control agents, and spray colorants.

This work is especially necessary as a result of the development of new spray colorants and spray adjuvants, and recent research findings which indicate that spray thickeners may not be providing the control over droplet size that has always been assumed.

Alternate Insecticides

Two additional needs are to evaluate insecticides which have shown promise in laboratory studies as supplements to, or replacement of, those presently used, and to evaluate other control strategies which will result in less frequent application of pesticides.

The need for alternative insecticides is a result of several factors, including proposed changes in pesticide registration, worker toxicity, potential adverse environmental impact and public concerns about pesticides presently registered for use in seed orchards. For example, **granular carbofuran** is presently under special review by the Environmental Protection Agency as a result of excessive bird mortality and potential ground water contamination. This pesticide has been used extensively on seed orchards to control cone borers and seed bugs, and its loss with no replacement chemical available, would be unacceptable on many orchards. Worker toxicity is a concern especially when the insecticide **azinphosmethyl** is applied. **Azinphosmethyl** has a low LD_{50} (40-50 mg/kg) even when mixed in the concentration normally applied to seed orchards, and many orchard managers believe that the risk to workers is too high to justify its use. **Fenvalerate**, the third most commonly used insecticide, has caused severe infestations of scale insects as a result of the reduction in scale parasites and predator populations that follow its application.

The chemicals we propose to evaluate are less toxic to mammals and generally present less threat to non-target organisms and the environment than those presently being applied.

There are four insecticides and one insect growth regulator we need to evaluate under field conditions. **Chlorpyrifos (Dursban 4E)** shows excellent potential for controlling several seed and cone pests. It is already registered for use in forestry applications, but the rates, timing, and application methods most suitable for use in seed orchards need to be evaluated. **Chlorpyrifos** has been successfully produced in an encapsulated formulation which appears to provide decreased exposure levels to workers and increased protection time for the seed crop.

Bacillus thuringiensis (Bt) has been evaluated in several small field tests and shows promise for controlling some **Dioryctria** cone worms. This is a very safe insecticide from both the human and environmental standpont. If we can successfully incorporate Bt into a control strategy, it would add a very acceptable tool from both the environmental and political standpoint.

Acephate (Orthene) has provided very acceptable control of slash pine flower thrips, and limited testing indicates good efficacy against several common cone worm species.

We need to evaluate **acephate** on a wider range of orchards and pests to identify its potential role.

Malathion is one of the least toxic organophosphate insecticides currently registered. It is widely used in programs where human exposure is high, e.g., mosquito abatement programs and in the citrus industry.

Malathion appears to have real potential as a substitute for **azinphosmethyl** in leaf-footed pine seed bug control. The product is readily available, has a low mammalian and non-target toxicity, and is relatively inexpensive.

The advent of third generation **synthetic pyrethrins** is an event FPM should be able to take advantage of. These compounds possess the low mammalian toxicity common to other pyrethroids, but may lack the impact on parasites and predators of scale insects we have found with the currently available **synthetic pyrethrins**. Their potential role in seed orchard pest management needs to be fully and carefully evaluated.

Although they are not pesticides per se, insect growth regulators have been very effective in small tests on several lepidopterous pests commonly causing damage to cones and seeds. They have also been effective in large scale control programs for Gypsy Moth, are registered for forestry uses, and are essentially non-toxic to humans and most non-targets.

Reduced Application Rates

In addition to evaluating alternative chemicals for insect control, it may be possible to increase control and reduce both worker and environmental risk by using lower application rates and timing applications differently.

The possibility of using application rates lower than those presently used appears to be a viable alternative for several pests; however, until definitive field tests can be implemented and evaluated, this premise cannot be explored. Several preliminary studies indicate that on orchards with only one or two species causing damage, fewer applications than the presently used 30 day schedule may be feasible; however, until several questions regarding developmental rates of life stages of the pest complexes are answered, orchard managers prefer to apply pesticides on a regular basis as insurance against crop losses.

Development of Biological Data Bases for Seed and Cone Insects

To accurately predict developmental rates, we need to gather data to create degree day models for each major seed and cone pest. This work is very labor intensive and must include information from across the geographical range of each insect. Normally, this would be a job for research but their personnel and financial shortfalls preclude this goal.

A critical portion of developing degree day models is the accurate monitoring of weather conditions specific to each orchard's micro-environment.

Sophisticated, expensive, continuous monitoring equipment is a necessary part of this effort. Timber Management has begun to install this equipment on FS orchards, however, the data base provided by these systems must be augmented by information from a wider base if we are to accurately predict insect developmental cycles region wide.

We also know that insect activity cycles vary by time of day. The possibility of adjusting application times to coincide with major activity cycles shows real promise; however, this work involves more commitment than is presently possible for either research or FPM.

Role of Pheromones

The role of **pheromones** in control programs needs careful evaluation. Forest Pest Management sponsored a very successful effort 5 years ago to identify **pheromones** produced by the **Dioryctria** species commonly causing seed and cone damage. The results of this project have been used to implement a southwide survey system for specific **Dioryctria** pests; however, it has not been possible to evaluate the full potential for **pheromones** due to funding shortfalls. For example, with adequate funding, the role of **pheromones** as a technique for timing pesticide application could be developed as could their use to disrupt the mating process, and as a technique for trapping moths from small, isolated areas. The role of **pheromones** on seed orchards is one of the most necessary, yet currently unanswered questions we are faced with.

Evaluation of Safety Equipment

The evaluation of safety equipment currently recommended for protection of orchard workers is another problem area. Recent advances in safety clothing coupled with research findings relating to worker exposure levels have created the need for a project that will carefully define the most effective protective clothing for seed orchard workers. The ultimate goal of this project would be to develop a worker safety guideline manual for all seed orchard workers.

Proposed Projects

We are preparing the following studies as an initial effort at answering some of the questions previously mentioned.

The proposals are described in descending order to importance. Fragmented efforts have been made in some of the proposal areas, (see appendix I), but we need definitive, region-wide studies to fully resolve the problems.

The improvement of aerial application technology would provide the most benefit, for the most orchards, in the shortest time. We need to pursue the following objectives in this area:

1. Compare currently used rates to lower rates. The reasoning for this need and the results have been discussed previously. The role of more frequent applications at lower rates would also be evaluated.

2. Evaluate the use of ULV in seed orchards. The use of ULV technology may be the solution to current problems with worker exposure levels and relatively high costs associated with aerial application. ULV also has the potential for providing much better insect control than that which is currently available.

3. Compare one pass vs two pass applications. If acceptable, control can be achieved with one pass, and application costs would be halved.

This project would require 2-3 years for completion, depending on weather and initial results. Cost would be $40,000 for year 1, $22,000 for year 2 and, if necessary, $20,000 for year 3.

The second major study area is an extension of the pheromone project. Dioryctria merkeli would be the primary pest evaluated, since D. merkeli populations are increasing rapidly southwide.

The major objectives for the study are:

1. Evaluate the use of pheromones to establish seasonal and daily activity cycles.

2. Use pheromone trapping to evaluate the efficiency of pesticides currently used to control this pest.

3. Monitor the effectiveness of a single application per season versus multiple applications.

This project would last approximately 2 years, and would cost $20,000 for the first year and $8,000 for the second year.

The third major project is the evaluation of new pesticides for efficacy and safety. We need to evaluate the effect of encapsulation on reducing worker exposure while maintaining acceptable control. Research would play a major role in this area.

The four candidate pesticides are: malathion, orthene, Dursban 4E, Asana and Bt. These materials would be compared to Guthion for efficacy and residue decay times.

The study would span 2 years, and could cost $30,000 for the first year and $20,00 for year 2.

These three major studies could be combined, resulting in a significant cost savings. Combined cost would be $79,200 for year 1, $42,000 for year 2, and 18,000 for year 3 (See Appendix II), resulting in a savings of $20,000 over the next 3 years.

A contingency proposal for FY 1987 could be formulated based on satisfying our most pressing need; e.g., the improvement of our aerial application technology. The cost of this project and the cooperators involved are detailed above and in Appendix II. As funds allow, the two other proposed projects would be phased in. There are additional areas where FPM specialists and NFS orchard managers have identified significant gaps in our pest management abilities.

Other projects we feel are important to our seed orchard pest protection activities include:

1. Development of degree day models to predict emergence times for each pest species. This information is critical if we are to develop a functional IPM approach to seed orchard pest management. We have begun using degree day models developed at the University of Georgia to audit emergence of tip moths (Rhyacionia species) in our shortleaf pine seed orchard, and have both reduced the number of pesticide applications/year and improved our control. A proposed budget for the most important species, **Dioryctria merkeli,** for the expansion of this work is as follows:

	FY 88	FY 89	FY 90
1.	Gather data for D. merkeli life span	Gather data for merkeli Input to model	Gather data Input to model Validate model
Cost:	$30,000	$20,000	$10,000

Cooperators	Input
1. SE (Athens, Georgia)	Technical assistance
2. University of Georgia Department of Entomology	Provide technician to input/analyze
3. Georgia Kraft Company	Provide study site

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	Technician support
4. NF-SC, Francis Marion Seed Orchard	Provide study site Technician support Bucket truck
5. R-8 Timber	Provide funds for technician ($5,000)

This work would continue until predictions have been developed and validated for all 6 of the major species of coneworms affecting southern pines. Our expertise in using species specific **pheromones** would also be heightened during this project, since they are the primary means for capturing emerging moths during the validation phase of the work.

2. Gather biological information necessary for developing control strategies for:

a. slash pine flower thrips

b. white pine cone beetle

c. seed bugs

d. cone borer

e. tip moth

Data acquisition and evaluation for the insects in this category would require at least 7 - 10 years for completion; and would necessitate significant input from FIDR. Meaningful assistance from FIDR has been lacking for the last 5-6 years , primarily as a result of the money and manpower shortages mentioned previously.

Gathering biological data is not as expensive on an annual basis as some of the other proposals discussed here, but the long term financial commitments are significant. Regardless of the species involved, a continuous program designed to define the biology of the seed and cone insect pest complex would require approximately $25,000.00 per year for the 7 - 10 years of the project.

Cooperators	Input
1. R-8 Timber	Provide study site, technician support
2. SE (Athens, Georgia)	Technical assistance, data analysis
3. SO (Olustee, Florida)	Data collection, data analysis
4. Virginia Division of Forestry	Study site, data collection
5. Georgia Kraft Company	Data collection, study site
6. Continental Forest Industries	Study Site, data collection
7. South Carolina Forestry Commission	Study site, data collection

These insects cause significant economic damage to southern pine seed orchards each year, though the damage caused by any given species varies from year to year and orchard to orchard.

There are several species of insects, especially those damaging seedlings, such as tip moths and reproduction weevils, that we expect to increase in importance in the next few years as we establish five seedling seed orchards in R-8. The addition of these new seed orchards to our responsibility is going to greatly increase the demand for our time, especially in solving insect problems peculiar to the new orchards. We are receiving limited funding from TM in the Region to support our efforts in some areas, but the scope of the problems are such that the Region cannot support all the work alone. We will appreciate WO assistance in funding these high priority projects.

3. Transferring the technology developed during this program will be a continuous process. The majority of the information dissemination effort will be via personal contact with users; however, there are several regularly scheduled meetings that include seed orchard managers and other key personnel where FPM has historically discussed the state of the art in seed orchard pest management.

These meetings include:

1. Annual R-8 seed orchard managers meeting

2. Annual meetings of the Gulf Coast and North Carolina State Tree Improvement Cooperatives

3. The Southern Forest Insect Work Conference

4. Entomological Society of America

Publications will also be used to inform users. Two primary types of publications will be used:

1. Those produced in-house, e.g., Technical Reports, Fact Sheets and Newsletters.

2. Scientific literature, including the Southern Journal of Applied Forestry, publications of the Entomological Society of America, as well as state Entomological Societies. Funding for these efforts will be minimal, approximately $2,000.00/year for FY 89 - 94.

Long term funding to provide an acceptable rate of progress in solving seed orchard pest management problems and in developing, refining and implementing an IPM strategy for seed orchards would cost approximately $120,000.00/year, when all factors are considered. The costs would be apportioned as follows:

1. Technician support for 2 seed orchard Entomologists	$30,000.00
2. Maintenance for 2 bucket trucks	10,000.00
3. Special projects for 2 seed orchard Entomologists	80,000.00
	$120,000.00

Travel

This budget, when supplemented by contributions in kind from Timber and our university, company and FIDR cooperators, will enable FPM to keep abreast of evolving problems in seed orchard pest management.

APPENDIX I

Role of other agencies.

Other agencies have initiated efforts in some of the areas discussed; however, their findings are not generally applicable southwide for the following reasons:

1. If the study is to evaluate pesticide timing or efficacy, EPA won't grant any general or southwide registration based on data from only one or two sources. Generally FPM has coordinated these kinds of efforts southwide to ensure uniform test procedures and expression of results.

2. Studies to define life cycles must be implemented throughout the range of an insect pest e.g., D. merkeli, since time of emergence is related to degree days and is a function of geographic location.

Examples of contributions from other agencies are as follows:

TOPIC	OUTPUT	INTERESTED ORGANIZATION
1. Use of Bt on seed & cone insects	local studies	Chesapeake Corp.
	local studies	Champion Paper
	local studies	FL Div. Forestry
2. Evaluation of Imidan	limited studies	VA Div. Forestry
3. Biology & Control of thrips	limited studies	St. Joe Paper Co. International Paper Champion Paper Co. FL Div. Forestry SEFES
4. White Pine Cone Beetle	limited studies	NC Div. Forestry TN Div. Forestry VA Div. Forestry

Appendix II - Proposed Studies

1. Improve Application Techniques

Cost

	FY 87	FY 88	FY 89	Totals
Combined	$38,000	$18,000	$18,000	$74,000
Uncombined	40,000	22,000	20,000	82,000

Cooperators	Contributions
Weyerhauser	Provide study area, technicians, bucket truck
SE (Athens, Georgia)	Professional time, technicians
Mobay Chemical Corporation	Chemicals
University of Georgia	Pesticide residue analysis
NA (Dick Reardon)	Technician, application equipment
R-8 Timber	Technician (15,000.00)

2. Evaluate the Role of Pheromones in Seed Orchard Pest Management

Cost

	FY 87	FY 88	Totals
Combined	$18,000	$6,000	$24,000
Uncombined	20,000	8,000	28,000

Cooperators	Contribution
SE (Athens, Georgia)	Technician support, data analysis
University of Georgia	Pesticide residue laboratory, technician support, provide pheromone
Virginia Division of Forestry	Study site, technician
Georgia Kraft Company	Study site, technician

3. Evaluate New Pesticides for Efficacy and Safety

Cost

	FY 87	FY 88	Totals
Combined	$23,200	$18,000	$41,200
Uncombined	30,000	20,000	50,000

Appendix B

Committees 1992
Recommendations

United States Department of Agriculture
Forest Service
Washington Office
2121 C Second Street
Davis, CA 95616

Reply To: 2150

Date: August 12, 1992

Subject: Recommendations - National Steering Committee Seed, Cone, and Regenerations Insects

To: Director, FPM
Thru: Assistant Director, FPM

This is the committee updated list of recommendations for 1992 from the National Steering Committee - Seed, Cone, and Regeneration Insects.

NATIONAL NEEDS - listed in order of priority with number 1 being the highest priority:

1. Develop and evaluate non-chemical control alternatives, to include burning, behavioral chemicals, and biological control methods, for managing seed, cone and regeneration insects.

2. a. Develop timing mechanisms for initiating insect control activities.

2. b. Develop monitoring and prediction systems for -

   Dioryctria spp.

   Cone beetles

   White pine cone borer and other *Eucosma* spp.

   Seed bugs (west)

   Douglas-fir cone gall midge

3. Determine impact and damage thresholds for -

   Seed bugs

   Cone and seed insects of western white pine, ponderosa pine, and white fir

   Complex of regeneration insects in ponderosa pine and lodgepole pine

   Western pine tip moth

4. Identify and evaluate new insecticides for managing seed, cone, and regeneration insects.

5. a. Conduct field studies for reduced rates of the insecticide Guthion ar other insecticides.

5. b. Identify, evaluate and develop pheromone application equipment and techniques.

6. Evaluate and validate coneworm spray timing model. (Note that model has been developed and is ready for evaluation and validation).

7. Improve application efficiency to seed orchards and wild collection sites. (Note that application efficiency is an important element to the success c National Needs numbers 1, 3, and 4).

8. a. Evaluate IPM simulation models for southern pines.

8. b. Implement IPM practices in southern pine seed orchards: install weather monitoring systems; record coneworm moth pheromone trap catch data; spray for seed bugs based on knock down sample data; time coneworm sprays according to pheromone trap thresholds and degree-day models; and develop and use IPM simulation model to assist with decision making.

Supplemental to this letter I have enclosed a letter report from committee member R. Scott Cameron of Texas Forest Service. Please note his progress report on the technology development project Simulation of Aerial Insecticide Sprays with Ground Equipment.

The next committee meeting is scheduled for March 9-11, 1993 at Placerville, California hosted by Nancy Rappaport, PSW.

John W. Barry

JOHN W. BARRY
Chairperson

Enclosure

cc: Committee Members
M. Weiss
J. Cota

Appendix C

Genetic Resource Program

United States Department of Agriculture | Forest Service | Washington Office | 14th & Independence SW
P.O. Box 96090
Washington, DC 20090-6090

Reply to: 2470-6 **Date:** December 15, 1992

Subject: Genetic Resource Program (formerly tree improvement program)

To: Regional Foresters

A copy of the Genetic Resource Program Strategic Action Plan is enclosed for your information and use. This Plan was developed by geneticists representing the National Forest System and Research, silviculturists, seed orchard managers, an ecologist, and representatives from two tree improvement cooperatives and a University.

National Forest System geneticists have frequently been stereotyped as only caring about breeding trees that will grow faster and produce more solid wood and fiber. While this function is still important, geneticists have much more to offer in dealing with plant and animal species. Our hope is that this plan will bridge the barriers, reduce functionalism, and foster decisions that will ensure the sustainability of plant and animal species and wise use of our renewable resources. The document addresses the changing Forest Service environment, and supports the Chief's agenda for Ecosystem Management and implementation of Forest Plans.

The Strategic Action Plan focuses on five primary areas that fall under the Genetic Resource Program umbrella: genetic conservation, ecosystem management, tree improvement, education, and partnerships. These imperatives represent critical areas where the technical expertise of our forest geneticists should be used to aid in sustaining healthy and productive ecosystems. Several goals are listed for each imperative, and specific actions are listed for each goal. The magnitude of the Genetic Resource Program will vary from Region to Region depending on biological and resource needs as described in Forest Plans. Each Region is encouraged to add actions that will contribute to improving the quality of Forest Service programs.

In July 1993, we will survey the Regions to determine the effectiveness of 7his Plan. The experiences will be summarized and sent to all Regions for their use.

/s/DAVID L. HESSEL
DAVID L. HESSEL
Director, Timber Management

FS:TM:R.MILLER:205-1250:12/02/92CONCURRENCE:R.Miller:12/02/92

GENETIC RESOURCE PROGRAM

PREAMBLE

The Genetic Resource Strategic Plan has been developed to focus the geneticists' activities over the next five to ten years. The plan provides guidance as to the subject areas and information that we can contribute to Forest Planning and RPA. It is a dynamic document that recognizes and addresses the changing Forest Service environment. This plan supports the Chief's agenda for Ecosystem Management, and implementation of Forest Plans.

The Strategic Plan focuses on five primary areas: genetic conservation, ecosystem management, tree improvement, education, and partnerships. These imperatives represent critical areas that we must embrace if we are to retain the opportunity to contribute knowledge on the genetic resources for sustaining healthy and productive ecosystems. Within each imperative are several goals, the broad areas we must focus on over the next five to ten years. Each goal includes specific action items (measurable activities) that must be accomplished if we are to achieve our goals. The magnitude of the genetic resource program implemented in each Region will vary depending upon biological and resource needs as described in Forest Plans.

The Strategic Plan will be only as effective as the support it receives from our people. The plan was crafted by geneticists representing the National Forest System and Research, seed orchard managers, silviculturists, an ecologist, and representatives from two tree improvement cooperatives and a University. The plan is imperative to the sustainable management of National Forest System lands, and for the production of products for use by the American people.

OUTLOOK

Provide leadership and expertise to incorporate genetic principles into ecosystem management. Provide appropriate genetic material to restore, maintain and enhance genetic quality. Sustain and/or increase diversity, productivity, and health of ecosystems in support of program management goals.

IMPERATIVE I

Genetic conservation today will provide flexibility in the future...
We will provide leadership in developing and implementing genetic conservation and genetic resource management programs for plant and animal species.

Strategic Goal A. Develop policies and guidelines to ensure biodiversity and adaptive capability are maintained for native and non-native plants and animals.

1. Develop seed transfer guidelines for native and/or introduced woody and herbaceous plant species.

2. Establish and evaluate appropriate genetic tests and other technologies to measure genetic diversity of plant and animal species.

3. Determine (survey) and prioritize the plant and animal species that should receive emphasis. Assimilate existing knowledge of the species.

Strategic Goal B. Provide guidelines for genetic reserves and genetic libraries for plant and animal species.

1. Inventory patterns of genetic variation within and among populations of species (literature, isozyme studies, common garden studies, etc.)

2. Use appropriate analysis methods for a landscape approach to assess need for reserves, size, etc.

3. Determine appropriate long-term management methods for <u>in situ</u> reserves.

4. Determine methods for long-term storage (<u>ex situ</u>) of genetic materials, e. g. seed, pollen, cuttings, tissue, etc. in addition to and to complement the <u>in situ</u> reserves.

5. Develop GIS layers to include patterns of within-species variation to better integrate genetic principles into Ecosystem Management.

Strategic Goal C. Develop policies for using genetic principles to maintain threatened, endangered, sensitive, and special emphasis species (TES).

1. Assimilate appropriate genetic knowledge of TES species.

2. Work closely with other biologists and specialists.

3. Initiate population viability analyses to determine appropriate population sizes and placement, and affects of management strategies on genetic systems.

4. Establish administrative studies to carry-out and monitor effectiveness of the program.

Strategic Goal D. Restore, maintain or enhance adaptive capability and genetic diversity among and within populations of species.

1. Develop propagation and/or breeding programs to maintain species viability and structure of genetic variation to ensure adaptation to changing future environments.

IMPERATIVE II

Genetics is the foundation of all life...
We must integrate genetic principles and technology into all aspects of ecosystem management.

Strategic Goal A. Incorporate genetic principles into the development, implementation, and monitoring of forest plans.

1. Become an active participant in the forest planning process--development, decision, and/or amendment.

2. Incorporate appropriate direction into forest plans for consultation with geneticists on vegetation manipulation including regeneration, restoration and recovery.

3. Incorporate forest planning into geneticists job descriptions.

4. Participate in forest plan inventory and monitoring process.

Strategic Goal B. Incorporate genetic principles relating to plants and animals into other resource activities in addition to the forest plans.

1. Participate in appropriate Administrative Studies.

2. Remain or become involved in appropriate region/nationwide programmatic planning, e. g. orchards and nursery, and TES listing and recovery programs.

3. Provide genetic interface for appropriate recovery plans.

4. Provide genetics knowledge as related to forest health and other initiatives.

5. Evaluate manual and handbook direction.

6. Incorporate genetic considerations into ecosystem classification and inventory.

Strategic Goal C. Develop and strengthen relationships between genetics and other resource disciplines.

1. Become member of appropriate Interdisciplinary (ID) Teams.

2. Participate in personnel selection panels.

3. Participate in other resource area workshops.

4. Participate in silviculture certification panels.

5. Apply technology at the National Forest Genetics Electrophoresis Laboratory (NFGEL) to other plant and animal resource areas.

6. Develop expertise of geneticists through workshops, etc. to market NFGEL services to other areas.

7. Participate in reviews (site-specific, forest plan, etc.)--consider participating in non-traditional areas.

8. Invite other resource areas to genetics workshops (host joint meetings).

9. Evaluate organizational structure--is it a best fit in your Region?

10: Hire geneticists with specific knowledge of population genetics to work in programs other than tree improvement.

IMPERATIVE III

The production of wood products is part of our mission...
We must continue to maintain tree improvement programs to produce selected genetic materials and to provide genetic knowledge for appropriate tree species.

Strategic Goal A. Determine and maintain appropriate levels and objectives for existing tree improvement programs.

1. Identify seed/seeding needs.

2. Perform economic analysis relating to expected gains.

3. Establish and evaluate genetic tests.

4. Review Regional programs as to workload, appropriate size, and budgets.

5. Evaluate genetic worth of genotypes in seed orchards.

6. Maintain genetic material and existing tree improvement records (data).

7. Retain core tree improvement expertise.

8. Continue deployment of seed and plant materials according to transfer guidelines and refine guidelines as information becomes available.

Strategic Goal B. Develop and refine tree improvement programs as needed to meet future objectives.

1. Consider alternative traits and species.

2. Solicit input from other disciplines to become informed about desired species and traits.

3. Develop more efficient screening and selection processes.

4. Evaluate genotypes in multiple environments to meet changing needs and other management objectives.

5. Determine validity of existing tests to achieve future objectives--other resources and/or traits.

6. Establish gene banks/clone banks to conserve diverse genetic material and consider other ways to maintain genetic materials.

Strategic Goal C. Develop new seed and plant material, and appropriate transfer guidelines for species in present and future programs.

1. Establish common garden studies and other appropriate genetic tests in order to develop transfer guidelines--use NFGEL as appropriate.

2. Collect, analyze and publish current data.

3. Estimate risk associated with using maladapted reproductive material.

IMPERATIVE IV

Our employees and the public need information on genetics...
We must improve understanding through education, technology transfer, and communication of genetic resource management both internally and externally.

Strategic Goal A. Provide general knowledge of concepts and philosophies of genetics programs to Forest Service employees.

1. Produce a video/ pamphlets/ handouts/ poster.

2. Field trips to genetic demonstration areas.

Strategic Goal B. Provide technical aspects of genetics programs and their applications in Ecosystem Management to resource personnel.

1. Contribute to workshops in other resource areas.

2. Participate in Forest planning process and ID Teams.

3. Participate in silvicultural certification programs as instructors and students.

Strategic Goal C. Provide continuing opportunities for education for genetic resource specialists.

1. Maintain technical training programs.

2. Develop detail opportunities for different regions.

3. Develop internal newsletter for ideas, technologies, references "things that have worked".

Strategic Goal D. Develop general understanding of the benefits of genetic resource programs to external publics.

1. Produce a video/ pamphlets/ handouts/ poster.

2. Look for opportunities to speak to public service, special interest, schools/teachers groups.

3. Help Public Affairs Officers with media coverage of genetics programs/projects.

4. Look for opportunities to speak with teachers and students at all levels of education.

5. Field trips to genetic demonstration areas.

6. Include genetics in interpretative trails and centers.

7. Include interpretative signs at existing genetic tests.

8. Develop demonstration areas to show s

9. Describe genetic principles as they

Strategic Goal E. Establish a communication involved in genetic resource programs.

1. Promote participation with Federal, involved in genetic resource programs.

IMPERATIVE

Cooperation may help us achieve objectives mo We must maintain, improve, and expand linkages cooperative efforts in appropriate situations.

Strategic Goal A. Develop and improve linkage and other research groups.

1. Supply material and study sites.

2. Participate in implementing studies an

3. Invite other resource specialists to

4. Support existing and develop new Admi changing needs.

5. Inform research organizations of the needs.

6. Provide assistance to S&PF as request

Strategic Goal B. Identify projects and deve research.

1. Evaluate impacts of resource manageme

2. Include researchers in ad hoc plannin

3. Install growth and yield studies with

4. Work towards understanding resistance

5. Evaluate impacts of introduced (non-n ecosystems.

6. Develop and support studies respondin climate change issues.

Strategic Goal C. Utilize partners in projec

1. Develop joint progeny test projects.

2. Develop joint selection projects.

3. Exchange plant and animal material to further genetic analyses.

4. Establish partnerships and/or cooperatives to assist in achieving the goals and objectives of genetic resource programs.

5. Develop Memorandums of Understanding and Cooperative Agreements to carry out special projects (development of germplasm collections for example).

Strategic Goal D. Establish and enhance relationships with other organizations including State, University, Cooperative Tree Improvement Programs, and tribal governments.

1. Meet with other groups, agencies, cooperators, publics.

2. Participate, make presentations at their meetings.

3. Provide input to other organizations' strategic plans, goals, and directives.

Strategic Goal E. Develop and improve linkages with other Forest Service programs.

1. Provide material, analysis, data management, and expertise to the extent of our abilities and qualifications.

Appendix D

Letter to Mel Weiss re.
1995 Farm Bill Issues

United States Department of Agriculture

Forest Service

Washington Office

2121 C Second Street
Davis, CA 95616
PH (916) 551-1715
FAX (916) 757-8383

Reply To: 3400

Date: July 8, 1993

Subject: FPM Role/1995 Farm Bill

To: Mel Weiss
Assistant Director, FPM

This memorandum is an output of the meeting National Steering Committee - Seed, Cone, and Regeneration Insects held June 29 - July 1 in Placerville, CA. Understanding that you are gathering input for the 1995 farm bill the committee is directing recommendations for your consideration.

Forest Health and Ecosystem Management challenges traditional single disciplinary approaches to resource management. Or expressed in another way they provide opportunities that may open the door to innovative approaches for FPM to understand ecosystem functions and relationships to human and pest interactions in the ecosystem. This subject was discussed by the committee, specifically the need to authorize FPM an expanded role in taking a more inclusive ecosystem approach to pest management as described in Healthy Forests for America's Future - A Strategic Plan. In this context the committee recommends that the 1995 Farm Bill authorize specific expansion of FPM's role in the following activities:

1. Ecosystem Functions. Diseases, insects, and invasion of exotic plant species can easily be argued to be symptoms of an unhealthy ecosystem. To develop management control strategies for ecosystem balance, FPM specialist cannot ignore other functions, e.g., soil microorganisms and associated flora and fauna, air pollutants, and relationship of non-pest plants and animals to pests. Pests in this context are defined as non-native species and native species out of balance.

2. Ecological Surveys and Mapping. FPM should have an active role in contributing to the eco-database. Data traditionally collected such as extent of a pest outbreak is becoming less meaningful without the collection of additional geographical, environmental, atmospheric, climatic, and biological data that relate to or influence the outbreaks. Eco-data collected in this context can contribute to understanding outbreaks and development of pest models and strategies.

3. Pest Vegetation. This includes non-native species, native species out of balance, introduced plants, and naturalized plants. Such vegetation impacts on forest health and on a balanced ecosystem. The relationships need definition and understanding. FPM should have an active role in pest vegetation, particularly with biological control of pest vegetation with native insects, and in case of non-native plants, with "classic" biological

control systems. FPM should also be active in evaluating the relationship of pest vegetation to forest health.

Please let me know if you have any questions or feel free to contact any of the committee members directly for more information or clarification.

John W. Barry

JOHN W. BARRY
Chairperson

cc: Committee Members
N. Lorimer
J. Cota
D. Thomas
D.W. Johnson

Appendix E

Jim Stewart's Comments to
FPM Directors 1993
Meeting at Ft. Collins

Presentation to FPM Directors Meeting

Comments by Jim Stewart, Director FIDR

Ft. Collins, Colorado

February 9, 1993

Several months ago the Chief of the Forest Service announced a new policy for managing the National Forests. This new policy, called ecosystem management, calls for greater attention to ecological considerations when making management decisions. This new policy greatly impacts the way we deal with forest pests.

Once again our current technology for dealing with forest pests becomes less than satisfactory and new approaches are needed. A look back at the history of pest management reveals that we have faced this situation several times. Take bark beetles as an example. In the days before the development of chemical pesticides, control tactics for pine bark beetles were based on physical removal of susceptible and infested trees. Entomologists back then learned that during endemic periods, old or weakened trees were more susceptible to attack than were young, vigorous trees. Based on this knowledge, control schemes were designed around continuous survey for and removal of high risk and infested individual trees or small groups of trees. This approach was considered successful and an infrastructure developed that included driving through the forest looking for such trees and removing them. As years passed, however, experience demonstrated that this approach was economically and silviculturally undesirable. Economic conditions changed and it became too expensive to harvest individual trees scattered over large areas. Foresters also began to realize that the forest was being managed only by cutting individual and often mostly rotten trees and were deteriorating from overstocking and other problems. Foresters needed additional ways of dealing with bark beetles. Chemical pesticides were developed and these were accepted and considered to be successful for treating bark beetle infestations. For a couple of decades, armies of men went into the woods to spray the bark of standing or cut trees to kill the beetles. Eventually, environmental concerns and concerns over the impacts on natural predators and parasites began to surface. Costs were another factor. New ways were needed. Forest entomologists, continuing their research on the biology of the pest, refined the knowledge on what forest conditions were conducive to outbreaks and what conditions did not support an outbreak. They developed this knowledge into recommendations for thinning to maintain stocking levels that were not conducive to outbreaks and this was thought to be the answer to bark beetle problems. But, there are no panaceas and it soon became apparent that economics and forest management goals that precluded large scale thinning would prevent this technique from being applied in many areas. Something else was needed. Again entomologists are responding by developing the use of pheromones as a way of manipulating beetle populations.

With the passing of time, each "successful" treatment was found to be less than fully adequate and new ways were needed. In each case, entomologists in the Forest Service and the many cooperating universities and private companies developed new alternatives.

Another example of how forest insect control has progressed through the adequate-inadequacy cycle is the control of defoliating insects. Chemical pesticides like DDT were developed and were successful in controlling pests such as the gypsy moth and the spruce budworms. These pesticides were viewed as great successes and almost as panaceas. They had long residual effect and killed a broad spectrum of pests. Eventually, however, environmental issues became apparent and many of them were banned. Chemicals that would break down faster in the environment were called for. The chemical industries responded by developing such chemicals and forest entomologists adapted these into schemes for controlling defoliating insects. These chemicals were used for years against the budworms, gypsy moth and tussock moth, but they too came under environmental scrutiny and changes were called for. This time research responded with developing biological pesticides such as B.t. Now, concern is developing over the impact B.t. may have on endangered species of butterflies and pesticides with even narrower target species specificity are being called for.

Controlling forest diseases has gone through the same cycle. The control for dwarf mistletoes were developed and considered very successful. But, the strategy was based on the ability to clearcut heavily infested forests. Now, pressures against clearcutting make this strategy difficult to use and other ways must be developed.

White pine blister rust was introduced into the United States early in this century and threatened the stature of western white pine, and sugar pine, two important commercial species in western forests. Research pathologists had discovered that the fungus causing this disease required an alternate host, in this case members of the genus Ribes, in order to complete its life cycle. Using this information they developed the strategy to eliminate the alternate host and thus break the life cycle of the disease. As a result, armies of young men, many of them students working their way through college, combed the woods looking for and grubbing out ribes plants. Eventually, this strategy fell into disfavor because of costs and questions about its effectiveness when evaluated against absolute criteria such as, no ribes left and no new rust infections. New strategies were needed. Chemical fungicides were tried, but these failed to do the job. Pathologists and geneticists pursued the development of rust resistance trees. This was successful and millions of trees with varying levels of resistance have been and are being planted. But, concern now is developing over the fact that the rust fungus is variable and strains may develop that are capable of overcoming tree resistance. New types of resistance may now be needed. A similar story relating to resistance strategies for controlling southern fusiform rust can be told.

From the above it is apparent that the need for new pest management methods and approaches can be driven by experience revealing weaknesses in current methods and approaches and by changing public attitudes. There is a high public interest level concerning the management of forests in the United States. The public is no longer willing to have their forests primarily managed for forest uses such as timber production or recreation. Today, the public uses terms like ecosystems, ecology, natural, sustainability, landscape scale, biodiversity, and endangered species when they try to describe for what and how forest should be managed. And now we have the Chief's new policy.

Foresters today are faced with the challenge of managing forests with prescriptions that are more ecologically based and sensitive to all the values in forest ecosystems. This means that many once successful approaches to managing forests and their pests and diseases are no longer acceptable and new approaches and methods are needed. We must come up with new control tactics that are compatible with ecosystem management objectives, and we must provide a better understanding of forest ecosystems as influenced by and related to insects, other arthropods, diseases and microorganisms. With this in mind, I recently prepared a summary of what I think FIDR needs to be giving emphasis to now and for the next several years. A copy is attached.

Underlying my reasoning is the recognition that we must have a more complete understanding of forest ecosystems. Experience tells us that control methods that seem adequate and acceptable today may in fact be faulty in subtle ways that do not show up for several years. We have been naive thinking we can affect one part of an ecosystem without affecting other parts. We have viewed parts of ecosystems as independent and isolated when in fact all parts are interrelated and affecting one part affects another. Thus research must reorient its programs toward more basic understanding of ecosystems and ecosystem components.

At the same time, and don't ask me how we will respond to both, we need to me more responsive to answering immediate, practical problems. If nurserymen cannot use methyl bromide, they need a substitute and can't wait for several years while we learn all we need to know about nursery bed ecosystems. We need to come up with ways of dealing with new pests. The current list includes butternut canker, dogwood anthracnose, beech bark disease, hemlock woolly adelgid, and pine shoot beetle. If we stop to learn all we need to know before we develop control methods, we might lose the battle.

Along with the Chief's policy on ecosystem management, he has directed research scientists to spend more time being extension agents and working one on one with foresters as they develop management decisions. The objective is to ensure that the latest information is incorporated into these decisions. With a little tongue and cheek, I find this ironic. You and I have had several discussions over the years about FPM's increasing involvement in doing research. Now the change in roles is complete -- FPM doing the research and FIDR doing the extension work.

Seriously, we are taking this directive to heart. I am encouraging our FIDR scientists to visit foresters on the Districts and spend time with them. This could cause some heart burn between you and FIDR. To minimize this, we will need to coordinate even more closely with you. But, I feel the Chief's directive is a positive one. For too long, FIDR has viewed FPM as our client and not the forest manager. We are often an unknown part of the Forest Service, organized to provide information and technology for use by foresters in dealing with insects and diseases. We need to reconnect and make ourselves and our work known. By doing so, we will get a better appreciation for the problems and constraints facing foresters, we will be better able to define and prioritize research needs, we will be able to impart our knowledge directly to them, they will get a better understanding of the research process and constraints, and, I hope, they will voice more support for the need for forest insect and disease research than they currently do.

Finally, I would like to mention a few specific programs. The western bark beetle pheromone initiative is continuing. This year we allocated $500,000 to PSW, PNW and INT. We believe this effort, which is cooperative with several FPM units, is progressing well and we expect some definitive results by the end of this year.

We are initiating a new effort on pine shoot beetle at the NC Station and FPM is contributing to this. Bob Haack at East Lansing is the principal investigator. This will include determining host range (including southern pine species), basic biology, and behavior. This insect is an example of one introduced pest that is currently overwhelming our capabilities. The others are listed above.

We will be soon be coming to you to help in preparing a problem analysis for nursery pests, given the demise of methyl bromide. A USDA interagency research group has been formed to develop departmental plans for developing alternatives to methyl bromide. This effort will include problem analyses for each major commodity group followed by a workshop in June that will help narrow and prioritize research needs. We have asked Steve Fraedrich of the Southeast Station to do the forest tree nursery problem analysis and Dick Smith will be the Washington Office contact. We have already contacted FPM in Washington for your assistance.

We are trying to invigorate our research effort on biological control. Last year the department developed a biocontrol initiative that was presented to and verbally supported by the five involved agency heads and respective Assistant Secretaries. Unfortunately the powers that be could not see their way clear to include the FS part of the budget request in the Department's FS budget proposal to OMB. However, to guide our program with existing dollars, Bob Bridges is going to do an assessment of current research on biological control -- the needs and priorities for the future. Bob has already contacted Nancy Lorimer regarding FPM's interest in a joint effort to include development and application needs.

As you all know, we lost Frank Hawksworth a few weeks ago. Frank's life set an example for all of us. He was dedicated to his profession. He valued everyone and felt he could learn from everyone. He offered his knowledge to everyone. He always kept himself and the issues facing him in perspective. I hope each of you, in whatever way you choose, stop and think for a moment of Frank. Think of what he meant to you personally, to what you know, to the science of forestry and pathology, and to what you can learn from him and his life to make you a better person and contributor to forest pest management.

Rationale for Current FIDR emphasis areas

Ecosystems Management in the Forest Service is an ecological approach to achieving multiple-use management on the National Forests and Grasslands. Underlying the full implementation of this policy is the premise that there is a sufficient knowledge base concerning critical components of forest ecosystems.

The foundation of forest ecosystems, like the foundation of life for higher plants and animals in other systems, lies with small organisms (bacteria, fungi, nematodes) and arthropods. These play absolutely vital roles in maintaining healthy forest ecosystems. Yet, the base of knowledge concerning these roles is inadequate. Information is needed on identification and classification, what each organism's specific roles are, and how natural or anthropogenic factors influence these roles. It is very important that the FIDR program support the implementation of ecosystems management by filling these critical gaps in our knowledge base.

Filling these gaps in our knowledge base will also improve our ability to monitor for possible changes in forest health. We know that some native forest insects and diseases attack mainly weakened trees or forests and thus can be used as indicators that forests are under some kind of stress. In all probability, other arthropods and microorganisms are also sensitive to stresses and changes in their populations will provide earlier indications of declining forest health.

Although we need to take a more ecological view of forest insects and diseases and acknowledge that low level populations and even some outbreaks of native insects and diseases may have positive impacts on an ecosystem, foresters must have improved technology to prevent and suppress outbreaks that cause unacceptable damage and to eradicate or control potentially damaging exotic pests that gain entry to the United States. Improved technology is also needed for controlling insects and decay fungi that destroy wood in homes and other structures. The FIDR program needs to vigorously pursue the creation and development of this new technology. Classical biological control, encouragement of natural competitors, biological pesticides, behavioral chemicals, sterile insect release, endophytes, and genetic resistance using biotechnological approaches are examples of areas of opportunity.

Microorganisms that exist and play roles in forest ecosystems have beneficial uses outside these ecosystems. Some are capable of detoxifying chemically contaminated soils. Others may be used in making pulp at reduced energy costs. The FIDR program can use its skills and join with scientists in other disciplines to pursue opportunities to develop these uses, which have important roles to play in improving our Nation's environment and competitiveness.

FOREST INSECT AND DISEASE RESEARCH

PROGRAM AREAS NEEDING INCREASED EMPHASIS

IN SUPPORT OF THE FOREST SERVICE MISSION, AND IN RESPONSE TO ITS NEW POLICY ON ECOSYSTEMS MANAGEMENT, THE FIDR PROGRAM NEEDS TO INCREASE EMPHASIS ON:

Understanding the beneficial as well as harmful ecological roles and effects of native and exotic insects, diseases, other arthropods, and microorganisms in forest ecosystems; and developing options for using this knowledge in maintaining and enhancing forest health.

Developing more environmentally benign pest control methods that are compatible with ecosystem management goals.

Working with foresters and other users of research information to foster the application of new knowledge and technology in forest management decisions and practices, and to identify and gain an appreciation for additional research needs.

IN SUPPORT OF NATIONAL PROGRAMS TO IMPROVE THE ENVIRONMENT AND INCREASE ECONOMIC COMPETITIVENESS, THE FIDR PROGRAM NEEDS TO INCREASE EMPHASIS ON:

Cooperating with other scientific disciplines in developing technology for using forest microorganism to detoxify contaminated soils and to reduce energy and environmental costs in pulping processes.

12/23/92

Appendix F

Paper by Stephen E. McDonald

"Ecological Land Management: Its Implications for Reforestation and Nursery Operations"

Ecological Land Management: Its Implications for Reforestation and Nursery Operations[1]

Stephen E. McDonald[2]

Abstract.--Recent events have changed implementable land management practices a great deal in the western United States. This presentation examines the situation, current trends and forecasts the future as related to reforestation and nursery operations.

THE SITUATION

In only a few short years the range of land management practices that are socially acceptable has narrowed greatly. The agricultural paradigm of maximum commodity resource output has become, in many places unacceptable. This unacceptability is manifested in an interacting morass of laws, appeals, regulations and litigation leading to major restrictions of traditional land management options. The options most effected, such as clearcutting, rely on artificial reforestation to regenerate the stands harvested. So, the controversy and its manifestations have a direct effect of reducing or modifying the reforestation and tree nursery business.

In hindsight this change should be no surprise, except, perhaps, for its recent rapidity. Indeed the roots of what we are witnessing spring from the conservation movement of the late 19th and early 20th century that spawned the National Parks and Forests. While this movement attacked and spent much of its highly visible energies on battles such as those related to the regulation of private forest land use and other issues throughout the 1920's and 1930's, its less controversial forms became institutionalized and enculturated in America. Institutions such as the Park Service, Forest Service, Soil Conservation Service flourished as did State Forestry organizations, Soil Conservation Districts, etc. Concurrently, through these organizations and other means such as education and conservation groups, the wise and conservative use of natural resources became, in general, the accepted way of regarding such resources.

The rapid expansion of the economy of the Country during World War II and the post war period required use of natural resources to a degree unimaginable only a few years before. This period of heavy use, if not flagrant exploitation, combined with the political and social turmoil of the 1960's generated a resurgence of concern among the public about fundamental natural resource protection and integrity. People perceived that natural resources are finite and directly connected to our long term survival. This manifested itself in a series of laws regulating resource use beginning with the Environmental Protection Act of 1970. This was followed by many others such as the National Forest Management Act of 1976, The Threatened and Endangered Species Act, and various state forest practices acts that regulated or restricted land manager's discretion. This legislative momentum continues to this day.

At the same time scientists were learning more and more about forest ecosystems and the sensitivities of such systems. We know now that some of the apparently minor parts of an ecosystem are vital to its integrity. We know that ecosystems require diversity in their makeup to function properly and persevere. We know that man is impacting ecosystems, seriously, in ways we were not even aware of a few short years ago. Examples are acid rain, global climate change, groundwater pollution impacts. These scientific theories and findings have contributed in no small way to the public concerns about ecosystem degradation.

A salient event was establishment of Ecosystem-based Management as an operating policy in the U.S. Forest Service this summer. Connected

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[1]Paper presented at the Western Forest Nursery Association meeting, Fallen Leaf Lake, CA, September 14-18, 1992.

[2]Stephen E. McDonald is Program Manager at the Pacific Northwest Forest and Range Experiment Station, USDA Forest Service, Portland, OR.

to that policy was a restriction on clear cutting as a silvicultural alternative on most National Forests.

So, you can see, this trend in events has been underway for some time, but its full expression was, for a considerable period of time, muffled and somewhat suppressed by the overwhelming demand for forest products, traditions of heavy resource use, resource surpluses, and until recently, public complacency or apathy. Presently, as you can readily see in the newspapers land management policy is an arena of intense and major social and political conflict. Jobs are at stake and so is the quality of the environment. The land management issue is only part of a much larger debate about natural resource protection and preservation.

THE TRENDS

One way to try to predict the future is to examine trends and to try to project them into the future. So what are the trends related to the ecological land management that may effect the reforestation and tree nursery business?

A couple of major trends were mentioned in the The Situation section:

1. The trend toward more restrictive legislation and regulation of land use. This means more uncertainty about how we can manage lands. Indeed, what use the lands will be devoted to is open to question. There is much <u>uncertainty</u> about what the management land base will be and how that will affect reforestation as a business.

2. Science has advanced enough to make it apparent that the ecosystems we deal with are far more sensitive and complex that we thought. They may not be as tolerant of, or resilient to, man's impacts as we formerly thought. As we continue to delve into ecological processes we may find this to be increasingly true.

In addition, let me propose some added trends that will affect the reforestation business:

3. Wood prices have continued to increase and total demand for forest products will increase, but at a slower rate. Wood substitutes continue to become more competitive and widely used. Many old projections about wood demand and needs have been contradicted.

4. Social awareness and activism about ecological issues continues to grow. Forest land use allocation continues to shift toward recreation, wildlife and fisheries and water outputs. The "baby boom" generation is coming to power politically and seems to support this trend. There is an increasing emphasis on "natural" or ecologically based management of forests.

5. Wood is being intensively grown on acres particularly suited for it and of little use for competing purposes. Where intensive forestry is practiced, it tends to be <u>very</u> intensive.

6. More and more, forest tree nurseries are developing production schemes and marketing to take advantage of a diverse set of developing "niche" markets. Those that are most innovative and opportunistic are flourishing.

7. Reforestation has generally become smaller scale and more tailored to the needs of specific sites. Trees, shrubs and forbs are being planted in many cases for non-timber production purposes.

8. "Artificial Regeneration" as we have known and loved it now has a negative connotation in the minds of many of the public and connects to negatives such as monoculture, reduced biodiversity, destruction of scenic values, etc.

There are many other trends that could be discussed. This has been but a fragmentary and incomplete list. Some of these observations are debatable as to the scope and intensity of their effect. However, one thing is sure: we live in a time of <u>change</u> in forest management and wildland use allocations. The turbulence associated with this change process is disconcerting to many of us. It makes the future uncertain.

FUTURE SCENARIOS

Predictions about the future are risky because it is so hard to assess the probability of event occurrence. I have heard many forest managers predict that we are on the extreme end of a so-called "pendulum swing" in public attention and sentiment and that the pendulum will swing back to acceptance of what foresters consider traditional forest management activities sometime in the future. While this may be true to a modest degree as forest products prices rise, I think it is mostly wishful thinking and a way of avoiding reality. I suggest there are two main reasons to believe this:

1. The prolonged enculturation and activism of the American public in environmental affairs sketched in The Situation segment of this paper, which indicates this is no fad.

2. The fact that the forest management issue(s) are only part of a much larger, deeper, broader set of world environmental issues and concerns that command the attention of the public.

If this conclusion is accepted, any future scenario in the tree nursery and reforestation business has to deal with the current situation and the trends observable. Then we can begin to see realities of change which I think are:

1. Diminished large scale planting of a few species of forest tree seedlings.

2. More small scale projects of several plant species for not only timber production but for a variety of purposes.

3. More, smaller orders for plants of a specific, specialized nature, size, condition, etc.

4. Increased competition for what reforestation and nursery business there is and an oversupply of forest tree nursery capacity.

5. Broader political base possibly.

There may be more realities that you can think of that I have not, but those are enough to conjure up a scenario.

That scenario provides a nursery and reforestation industry that:

1. Provides a diverse set of tailored plant materials products in a responsive, custom, competitive way to a market made up of many clients with a variety of needs and expectations.

2. Has the capability to do any part of or all of the job. That means a complete revegetation job (from prescription through planting) or just part of it: custom seed collection, seed processing, contract propagation and rearing of various forms of plants, special micro-propagation, special plants of an unusual size or combination, etc.

3. Can survive on lower total production by providing specialized and custom services to a particular set of valued, perhaps long-term, customers, possibly by carving out a niche that the organization has a particular expertise in and reputation for.

4. Aggressively markets its services and competes in the nursery and reforestation marketplace, continually interacts with its clients, and survives by being opportunistic and adaptable.

In short this scenario projects a competitive, adaptable, full service industry that senses and responds rapidly and capably to it customers needs. This expertise, adaptability, aggressiveness, and flexibility enables it to survive in a lower volume, but higher product value market.

CONCLUSIONS

* Current situation: not a fluke or fad - the old days are gone.

* Trends: the trend toward demand for diverse plant material needs will continue.

* Future scenario: a time of change - nurseries need to become more entrepreneurial and opportunistic. Closer to the horticulture industry and ecologists at the same time and <u>clients</u>.

Appendix G

Field Trip

FIELD TOUR
NATIONAL STEERING COMMITTEE
FOR SEED, CONE, AND REGENERATION INSECTS

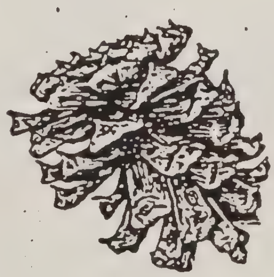
Thursday, July 1, 1993

8:30-9:00	Placerville Nursery Tour	Pat Trimble, Manager
9:00-9:30	Blister Rust Program	Safiya Samman
9:30-10:00	White Fir Aphid IPM Program	Les Ehler, U.C. Davis
10:00-11:30	DRIVE TO FORESTHILL	
11:30-12:30	Lunch, Foresthill Seed Orchard	
12:30-1:30	Tour Foresthill Seed Orchard	Larry Binder, Manager
1:30-2:30	Entomology research at FHSO	Jack Stein Nancy Rappaport

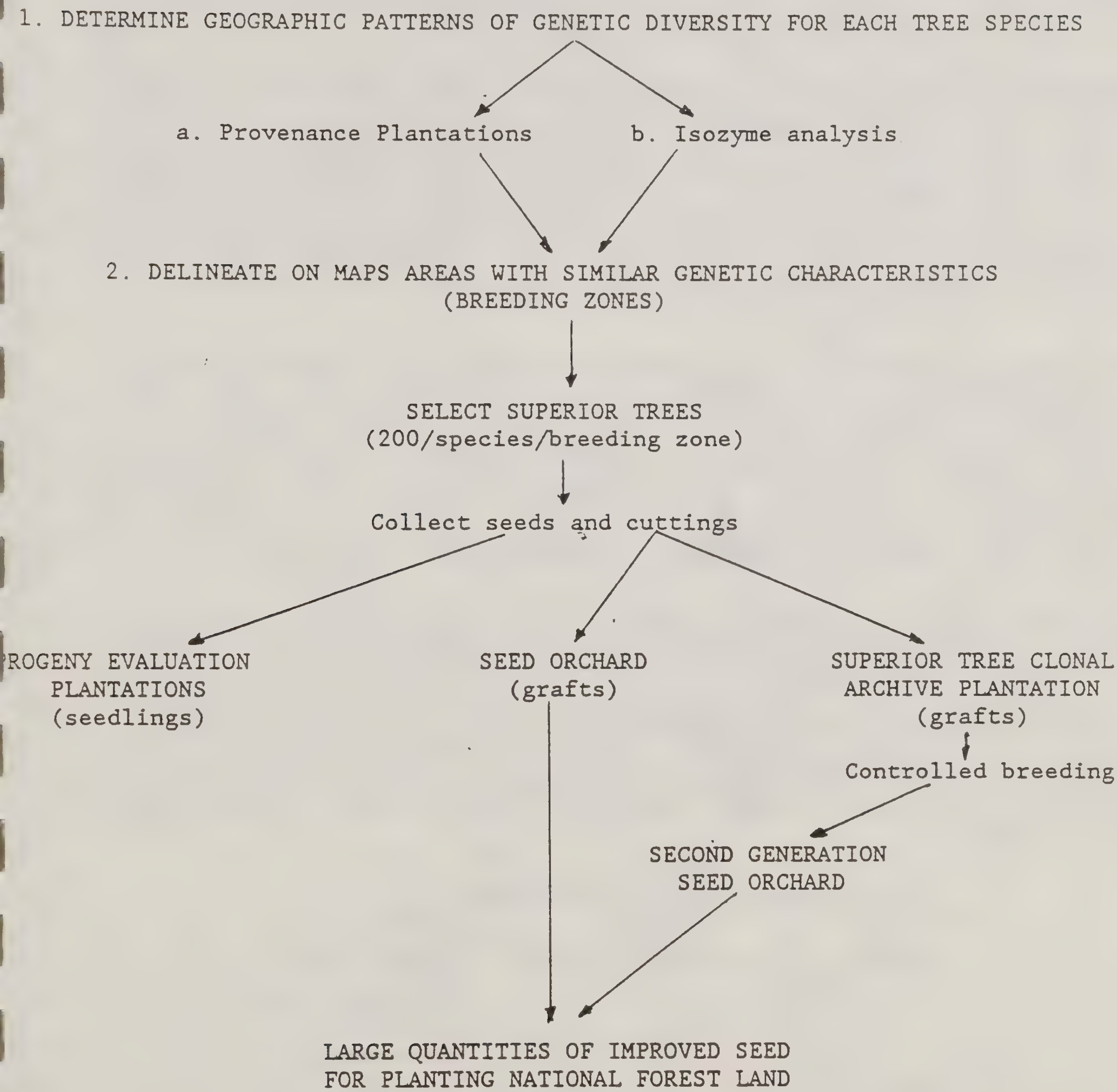
FORESTHILL FOREST GENETICS CENTER

Tahoe National Forest

Foresthill, California



FOREST SERVICE TREE IMPROVEMENT PROGRAM IN CALIFORNIA



INTRODUCTION

FORESTHILL FOREST GENETICS CENTER

The Foresthill Forest Genetics Center is one of four major facilities of the Forest Service's Pacific Southwest Region Tree Improvement Program. The site is administered for the Region by the Foresthill Ranger District of the Tahoe National Forest under supervision of the Central Zone Geneticist at Placerville Nursery. Direction for the Tree Improvement Program is given in the Region 5 Tree Improvement Master Plan (1976).

The primary objective of this facility is to raise genetically superior grafted trees and to harvest improved seed from those trees to be used for reforestation of National Forest land. Seven National Forests on the west side of the Sierras will be served by this orchard. They include the Sequoia, Sierra, Stanislaus, Eldorado, Tahoe, Plumas and Lassen. White fir, red fir, Douglas-fir and blister rust resistant sugar pine production seed orchards are being developed at Foresthill. These orchards will provide roughly 50% of the seed needed by the seven forests. At present 161 acres are planted with a total of 321 acres planned for development.

The Center is located in the foothills of the Sierra Nevada Mountains about 50 miles east of Sacramento at an elevation of 4200 feet. This site was selected in 1964 for several reasons. These include: 1) A highly productive forest growing site. The area is nearly level with a deep, well drained loam soil. Precipitation averages 50 inches per year. Site index is 90 with Dunning site class I. 2) The orchard is within close proximity of Placerville Nursery. 3) The area had already been cleared by a forest fire in 1960. 4) This and surrounding areas are in National Forest ownership.

The present facility (figure 1) consists of two white fir production seed orchards for Breeding Zones 1 and 2 (Tahoe, Plumas & Lassen and Eldorado-Stanislaus NFs), Clone Banks for superior Ponderosa pine from the 7 National Forests in the Sierras (the orchards are at chico), a clone bank of Ponderosa pine for the North Sierra Tree Improvement Association, a Sugar pine clone bank with clones from throughout the region, a major Giant Sequoia genetics study being carried out in cooperation with the School of Forestry at the University of California, Berkeley and a progeny test area. Table 1 shows the development schedule for Foresthill.

Table 1
SEED ORCHARD DEVELOPMENT AT FORESTHILL

Breeding Zone	Orchard Acres	Target Est. Yr.
DF-7 (L,P,T)	13	1990
SP-3 (L,P,T)	24	1994-00
4 (E,St)	32	1995-00
5 (Si,Se)	24	1995-00
WF-1 (L,P,T)	18	1989
2 (E,St)	20	complete(87)
3 (Si,Se)	9	1994
4 (K)	9	1995
RF-2 (T,E)	32?	1996
3 (St,Si)	26?	1997

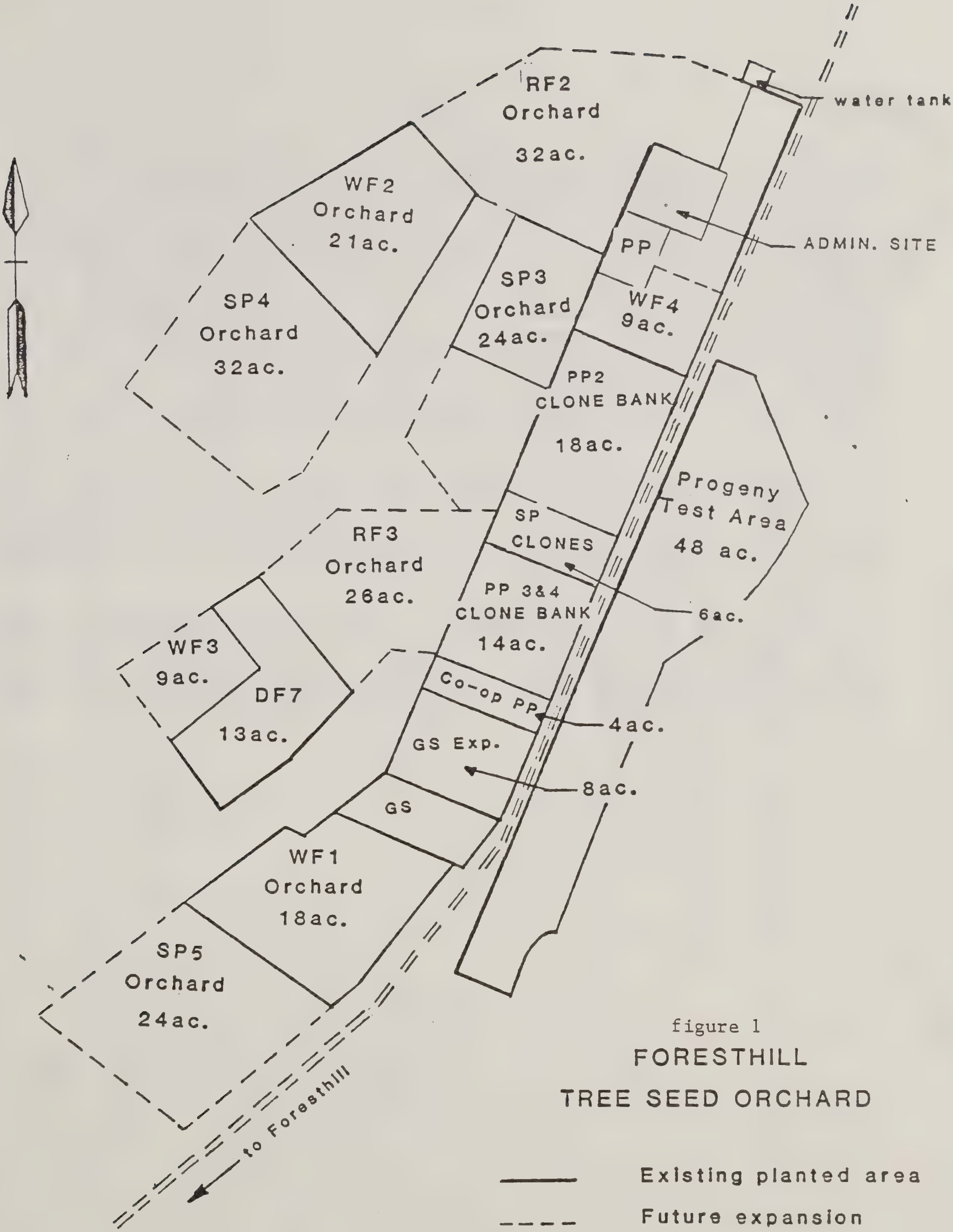


figure 1

FORESTHILL

TREE SEED ORCHARD

——— Existing planted area

- - - - Future expansion

Scale 1"=872'

HISTORY

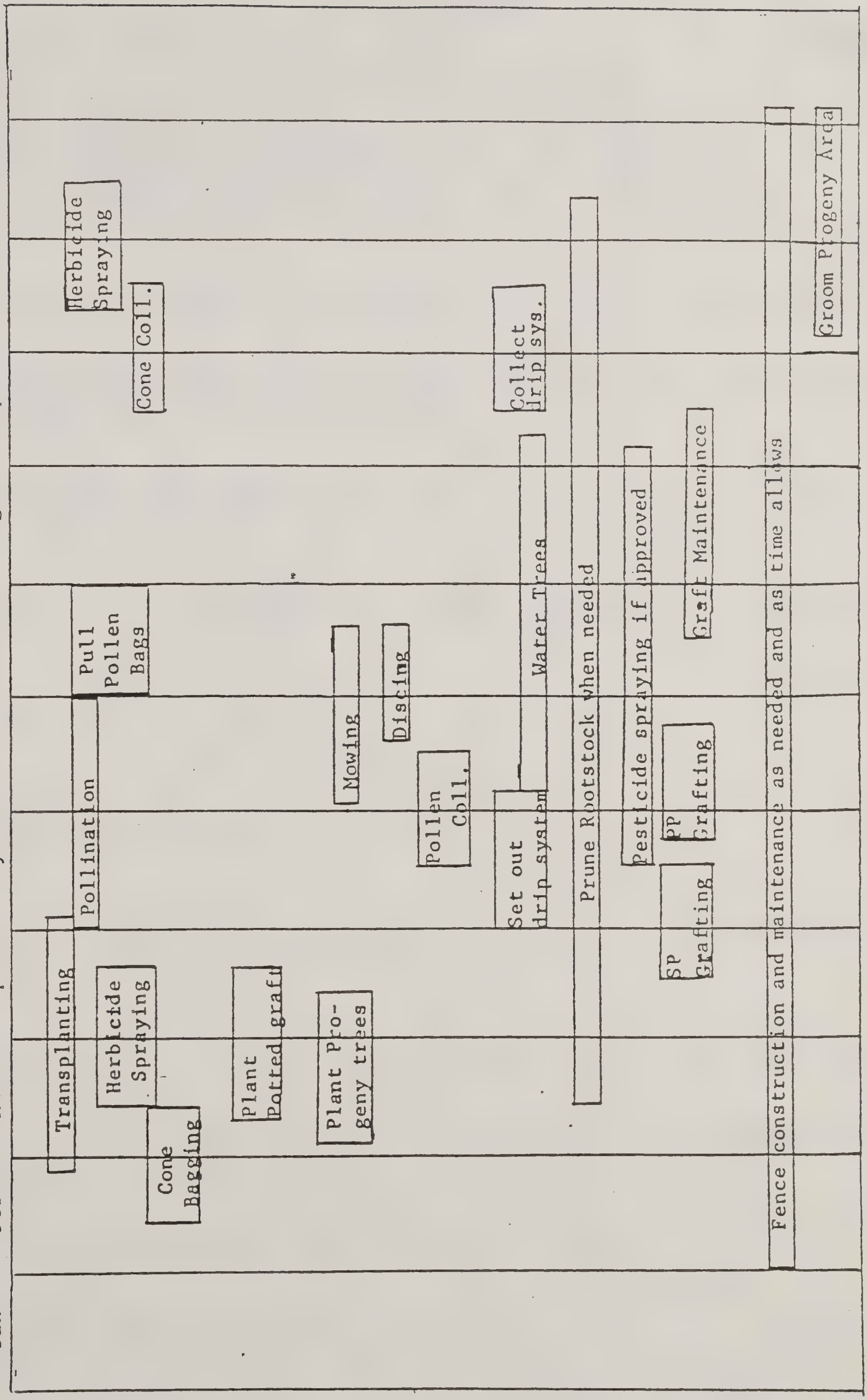
Foresthill was originally the Ponderosa pine seed orchard for the Region. The original orchards were established in 1965 and covered 74 acres. Alternating sugar pine and ponderosa pine orchards were field grafted onto previously planted rootstock between 1968 and 1975. A buffer strip 400 feet wide planted in white fir, Giant Sequoia and Douglas-fir surrounded the orchard to screen out contaminating pollens coming from the thousands of acres of pine plantations in the area. In 1976 the Master Plan analyzed the pollen contamination from the plantations and found it to be unacceptable. It was decided to move the pine orchards to the newly acquired Chico Tree Improvement Center and use the Foresthill site for pine clone banks and true fir and Rust Resistant Sugar pine orchards. To create room for future projects, and rearrange ramet locations the orchards were condensed into the smaller clone banks. This was accomplished by transplanting the trees between 1977 and 1981.

The first white fir seed orchard was planted in 1986. Grafting was done on potted trees at CTIC. Grafting success was over 90% when carried out under controlled greenhouse conditions. The trees were then shipped to Foresthill for planting. An isozyme analysis of seed from throughout the geographic area served by this orchard was carried out by PSW Experiment Station. The results of this study were used to design the orchard.

The Progeny Test Area was established in 1976 with the planting of a small white fir test and seedlings from the Placer County Giant Sequoia Grove. The first ponderosa pine test was planted in 1978 on a rectangular design. Since then more ponderosa pine, sugar pine and Douglas-fir tests have been planted but on an hexagonal design which allows for easy thinning.

Figure 7

Seed Orchard and Progeny Area Activity Schedule



CULTURAL PRACTICES

Irrigation	A permanent irrigation system was installed in 1980. A 3 inch diameter PVC mainline with 1 1/2 inch laterals furnish water to an above ground 1/2 inch black plastic drip system. Emitters or microtubing give 1 to 2 gallons of water per hour. Each tree receives 15 gallons once each 10 days. This will be increased for white fir and when the new water tank is built. Grafts are watered for 3 years after planting.
Spacing	Clone banks - 15'x15' rectangular, progeny - 7x7 hexagonal.
Fertilization	Quarter to half pound of 16-20-0 fertilizer spread around each tree at drip line in April and August.
Ground Cover	Orchard grass and Durar hard fescue were sown in the falls of 1968-69. the grass reduces brush invasion, controls weeds (thistle and mullen), keeps down dust and protects the soil from erosion.
Mowing	The Grass is mowed in July after it has gone to seed. This reduces fire hazard, makes for easier access and reduces competition.
Pruning	Trees are pruned up to 8 feet to facilitate the use of equipment and for fire protection.
Protection	A 4 foot fence surrounds the orchard to keep out cattle. Three foot high chicken wire cages are placed around new grafts to protect them from rabbit, deer and other brousing. Once the tree is 3 feet tall the cage is removed. Gophers are trapped or baited with strychine treated grain. The boles of newly transplanted trees were sprayed with Lindane or Sevimol 4 to protect them from bark beetle attack the first spring after transplanting. No major insect problems have occurred up to this time.
Fire Protection	A system of fuel breaks throughout the orchard and clone bank is maintained by discing. Grass is mowed and trees are kept pruned up. 1 1/2" Standpipes are located every 300' down the orchard for use as firetruck fillers.
Mulching	Grafts are mulched with bark or hydro-fiber mulch to protect soil moisture and reduce weeds.
Weed Control	Herbicides are sprayed 2 feet around grafted trees and broadcast sprayed in the progeny test before a test is planted. This removes weed competion for moisture and nutrients and reduces fire hazard. A dalapon-Atrazine mix, Simazine or round-up are most commonly used. Rototilling is used when herbicides cannot be used or have been ineffective in controlling the grass.
Tree ID	Each grafted tree is identified by a small aluminum tag nailed to the tree. Each tag tells superior tree number, seed zone and tree location number. Up-to-date inventories and maps are kept.

PINE CLONE BANKS

A clone bank is a location where clones of every superior tree from a breeding zone will be grown indefinitely. There are about 200 superior trees per breeding zone. Each tree has 4 ramets planted in the clone bank. These trees are used for controlled breeding and as a source of scion for future grafting.

There are four clone banks totaling 42 acres at Foresthill:

1. Ponderosa pine: Breeding zone 2 (Figure 4).
2. Ponderosa pine: Breeding zone 3 and 4 (Figure 4).
3. Ponderosa pine: North Sierra Co-op (See page 12).
4. Sugar pine: Some clones region-wide.

Most of the trees were transplanted to their present locations between 1977 and 1981. These trees were originally field grafted (1968-1975) to rootstock previously planted in the old orchards. The very large trees scattered throughout the clone banks are old orchard trees which were not transplanted. Field grafting is no longer done here. Scion is now grafted to rootstock planted in pots in greenhouses. After the graft has formed the tree is outplanted into the field.

TREE BREEDING PROGRAM

A large breeding program is carried out in the Ponderosa and sugar pine clone banks each year. Trees are controlled pollinated with each other using a 1/2 diallel mating scheme. The seedlings produced will be progeny tested and the best performers will be used in second generation seed orchards. Sugar pines are also pollinated with pollen from trees known to be resistant to white pine blister rust.

In late April flowers are covered with a paper isolation bag which has a plastic window in the side to allow viewing of the flower's development. When the flower is at maximum receptivity it is shot with pollen from a hyperdermic syringe. Two to three weeks later when the flowers have closed the bag is removed. Each flower cluster is tagged and flagged. The following spring a cotton bag is placed over the conelets to protect them from insects and allow for easy collection. In September the ripe cones are collected and sent to Placerville Nursery. Pollen for breeding is collected each spring and sent to the nursery for extraction and storage for future pollination. Approximately 3000 PP and 500 SP flowers are pollinated annually.

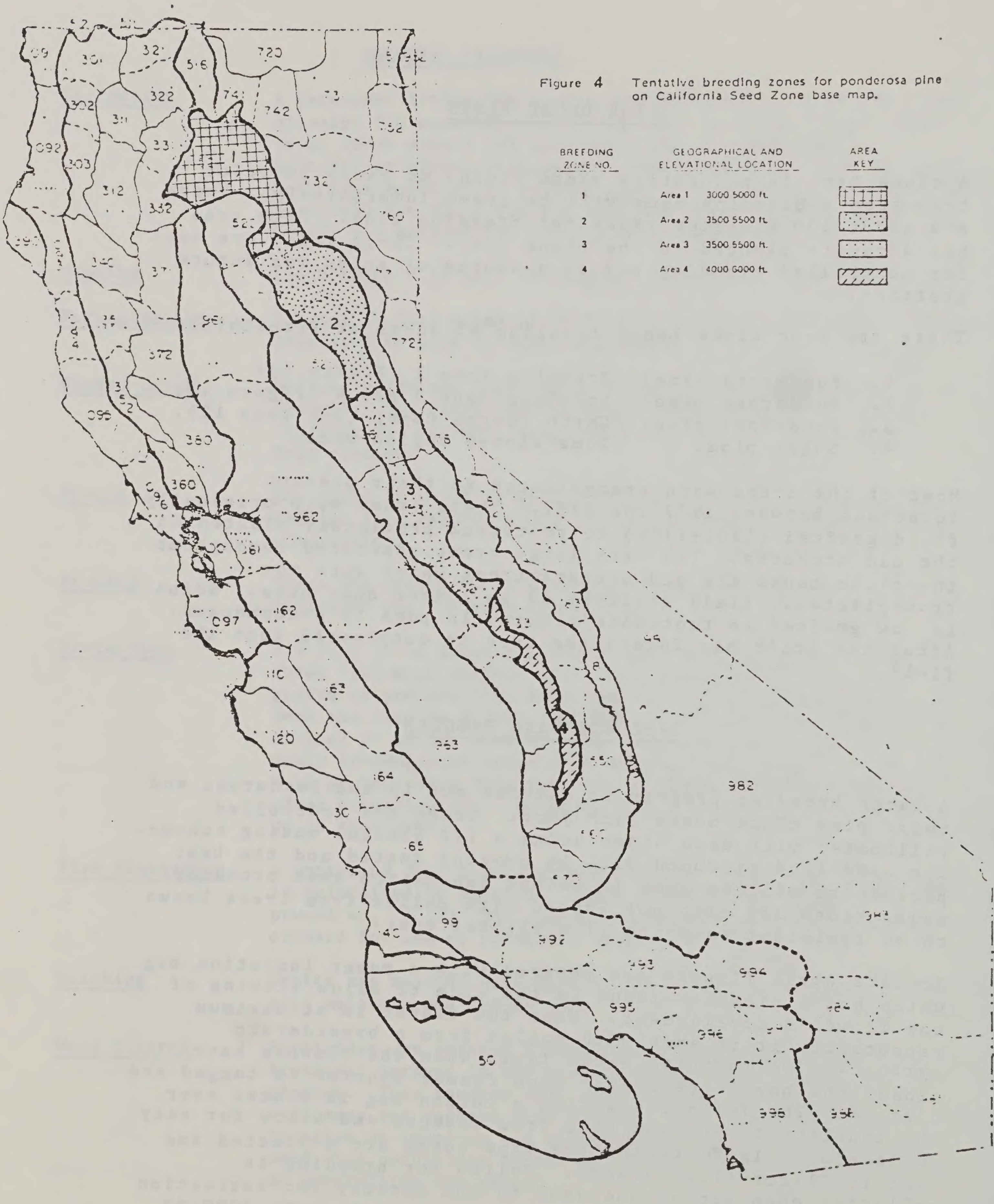


Figure 4 Tentative breeding zones for ponderosa pine on California Seed Zone base map.